1971

Iowa State University Bulletin, Graduate College Announcement, 1971-1973

Iowa State University

IOWA STATE UNIVERSITY BULLETIN

GRADUATE COLLEGE ANNOUNCEMENT 1971-1973

IOWA STATE UNIVERSITY
AMES, IOWA

GRADUATE COLLEGE

Announcement

1971-1973

IOWA STATE UNIVERSITY BULLETIN

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Contents

Administration of Iowa State University

The laws of the United States and of the State of Iowa provide for resident academic instruction, research, and extension education, and for the management of Iowa State University of Science and Technology. The University and two other state educational institutions of higher learning are governed by the State Board of Regents, composed of nine members nominated by the Governor of Iowa and confirmed by the Senate of Iowa. The immediate regulation and direction of the academic, research, and extension activities of the University are delegated by the Board of Regents to the president and faculty of the University. The Board appoints an executive secretary with over-all responsibility for the administration of the central office of the Board, located in Des Moines.

STATE BOARD OF REGENTS

Stanley F. Redeker, *President*

R. Wayne Richey, *Executive Secretary*

MEMBERS OF THE BOARD

Terms expire June 30, 1971

Casey Loss . . . . . Algona
Thomas A. Louden . . . . . Fairfield
William B. Quarton . . . . . Cedar Rapids

Terms expire June 30, 1973

Ned E. Perrin . . . . . Mapleton
Stanley F. Redeker . . . . . Boone
Ralph H. Wallace . . . . . Mason City

Terms expire June 30, 1975

Ray V. Bailey . . . . . Clarion
Mrs. H. Rand Petersen . . . . . Harlan
Donald H. Shaw . . . . . Davenport

OFFICERS OF ADMINISTRATION

WILLIAM ROBERT PARKS, Ph.D. . . . . President of the University

JAMES H. HILTON, D.Sc. . . . . President Emeritus

GEORGE C. CHRISTENSEN, Ph.D. . . . . Vice President for Academic Affairs

DANIEL J. ZAFFARANO . . . . . Vice President for Research
Dean of the Graduate College

WILBUR L. LAYTON, Ph.D. . . . . Vice President for Student Affairs

WAYNE R. MOORE, B.S. . . . . Vice President for Business and Finance

CARL HAMILTON, B.S. . . . . Vice President for Information and Development

FLOYD ANDRE, Ph.D. . . . . Dean of the College of Agriculture
Director of the Agriculture and Home Economics Experiment Station

VIRGIL S. LAGOMARCINO, Ph.D. . . . . Dean of the College of Education

DAVID R. BOYLAN, JR., Ph.D. . . . . Dean of the College of Engineering

HELEN LeB. HILTON, Ph.D. . . . . Dean of the College of Home Economics
Director of the Home Economics Research Institute

CHALMER J. ROY, Ph.D. . . . . Dean of the College of Sciences and Humanities
Director of the Sciences and Humanities Research Institute

RALPH L. KITCHELL, Ph.D. . . . . Dean of the College of Veterinary Medicine
Director of the Veterinary Medical Research Institute

ARTHUR M. GOWAN, Ph.D. . . . . Dean of Admissions and Records

MARVIN A. ANDERSON, Ph.D. . . . . Dean of University Extension
Director of the Cooperative Extension Service

C. ARTHUR SANDEEN, Ph.D. . . . . Dean of Students

University Calendar 1971-1973

FALL QUARTER 1971

September 1, Wednesday . . . . . Opening Faculty Convocation
September 1-2, Wednesday-Thursday, 8 a.m.-4:30 p.m.* . . . . . Registration
September 6, Monday . . . . . University holiday, offices closed
September 7, Tuesday . . . . . Class work begins
September 10, Friday, 4 p.m. . . . . End of fee payment period
September 16, Thursday, 4-6 p.m. . . . . Graduate English examination
September 27, Monday . . . . . Last day a student may drop a course without recommendation of instructor
September and October . . . . . Preclassification for Winter Quarter
October 8, Friday . . . . . Diploma slips due for Winter Quarter
October 9, Saturday . . . . . Educational Testing Service foreign language examinations
October 20, Wednesday . . . . . Thesis due in Thesis Office for initial checking
October 22-25, Friday-Monday . . . . . Homecoming, classes dismissed at noon Friday, resume 12:10 p.m. Monday
November 2, Tuesday . . . . . Last day a student may drop a course without extenuating circumstances
November 3, Wednesday . . . . . Last day for advanced degree final oral examinations
November 10, Wednesday . . . . . Final deposit of thesis in Thesis Office
November 17, Wednesday . . . . . Examinations begin
November 17, 18, 19, and 22, Wednesday-Friday, Monday . . . . . Registration
November 23, Tuesday . . . . . Examinations end
November 24, Wednesday . . . . . Graduation
November 25-26, Thursday-Friday . . . . . University holidays, offices closed
*Students in residence preceding quarter register during examination week of that quarter

SEPTEMBER

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
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OCTOBER

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31						

NOVEMBER

S	M	T	W	T	F	S
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DECEMBER

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5	6	7	8	9	10	11
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JANUARY

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23	24	25	26	27	28	29
30	31					

FEBRUARY

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27	28	29				

WINTER QUARTER 1972

November 30, Tuesday* . . . . . Registration
December 1, Wednesday . . . . . Class work begins
December 3, Friday, 4 p.m. . . . . End of fee payment period
December 9, Thursday, 4-6 p.m. . . . . Graduate English examination
December 21, Tuesday . . . . . Last day a student may drop a course without recommendation of instructor
December 21, Tuesday . . . . . Christmas recess begins
December 23-24, Thursday-Friday . . . . . University holidays, offices closed
December 31, Friday . . . . . University holiday, offices closed
December and January . . . . . Preclassification for Spring Quarter
January 3, Monday, 7 a.m. . . . . Class work resumes
January 14, Friday . . . . . Diploma slips due for Spring Quarter
January 22, Saturday . . . . . Thesis due in Thesis Office for initial checking
February 4, Friday . . . . . Last day a student may drop a course without extenuating circumstances
February 5, Saturday . . . . . Educational Testing Service foreign language examinations
February 5, Saturday . . . . . Last day for advanced degree final oral examinations
February 12, Saturday . . . . . Final deposit of thesis in Thesis Office
February 21-25, Monday-Friday . . . . . Examination week
February 21-24, Monday-Thursday . . . . . Registration for Spring Quarter
February 26, Saturday . . . . . Graduation
*Students in residence preceding quarter register during examination week of that quarter

SPRING QUARTER 1972

March 3, Friday* . . . . . Registration
March 6, Monday . . . . . Class work begins
March 8, Wednesday, 4 p.m. . . . . . End of fee payment period
March 16, Thursday, 4-6 p.m. . . . . . Graduate English examination
March 24, Friday . . . . . Last day a student may drop a course without recommendation of instructor
March 30, Thursday, 6 p.m. . . . . . Easter recess begins
March and April . . . . . Preclassification for Summer Quarter and Fall Quarter
April 4, Tuesday, 7 a.m. . . . . . Class work resumes
April 7, Friday . . . . . Diploma slips due for Summer Quarter
April 15, Saturday . . . . . Educational Testing Service foreign language examinations
April 22, Saturday . . . . . Thesis due in Thesis Office for initial checking
May 4-6, Thursday-Saturday (tentative) . . . . . Veishea—classes dismissed noon Thursday
May 5, Friday . . . . . Last day a student may drop a course without extenuating circumstances
May 6, Saturday . . . . . Last day for advanced degree final oral examinations
May 13, Saturday . . . . . Final deposit of thesis in Thesis Office
May 22-26, Monday-Friday . . . . . Examination Week
May 22-23, Monday-Tuesday . . . . . Registration for Summer Quarter
May 27, Saturday . . . . . Graduation
May 29, Monday . . . . . University holiday, offices closed
*Students in residence preceding quarter register during examination week of that quarter

MARCH							APRIL							MAY							JUNE							JULY							AUGUST						
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
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13	14	15	16	17	18		9	10	11	12	13	14	15	14	15	16	17	18	19	20	11	12	13	14	15	16	17	9	10	11	12	13	14	15	13	14	15	16	17	18	19
20	21	22	23	24	25		16	17	18	19	20	21	22	21	22	23	24	25	26	27	18	19	20	21	22	23	24	16	17	18	19	20	21	22	20	21	22	23	24	25	26
27	28	29	30	31			23	24	25	26	27	28	29	28	29	30	31				25	26	27	28	29	30		23	24	25	26	27	28	29	27	28	29	30	31		
							30																					30	31												

SUMMER QUARTER 1972

June 5, Monday* . . . . . Registration
June 6, Tuesday . . . . . Class work begins
June 7, Wednesday, 4 p.m. . . . . . End of fee payment period
June 15, Thursday, 4-6 p.m. . . . . . Graduate English examination
June 16, Friday . . . . . Last day a student may drop a course without recommendation of instructor (First Session)
June 29, Thursday . . . . . Last day a course may be dropped without extenuating circumstances (First Session)
June and July . . . . . Preclassification for Fall Quarter
July 4, Tuesday . . . . . University holiday, offices closed
July 11, Tuesday . . . . . Diploma slips due for Fall Quarter
July 11, Tuesday . . . . . First Session ends
July 11, Tuesday . . . . . Registration
July 12, Wednesday . . . . . Class work begins
July 12, Wednesday . . . . . Thesis due in Thesis Office for initial checking
July 13, Thursday, 4 p.m. . . . . . End of fee payment period
July 20, Thursday, 4-6 p.m. . . . . . Graduate English examination
July 20, Thursday . . . . . Last day a course may be dropped without recommendation of instructor (Second Session)
July 22, Saturday . . . . . Educational Testing Service foreign language examinations
July 26, Wednesday . . . . . Last day for advanced degree final oral examinations
August 2, Wednesday . . . . . Final deposit of thesis in Thesis Office
August 3, Thursday . . . Last day a course may be dropped without extenuating circumstances
August 15, Tuesday . . . . . Second Session ends
August 16, Wednesday . . . . . Graduation
*Students in residence preceding quarter register during examination week of that quarter

University Calendar 1971-1973

FALL QUARTER 1972

To be announced . . . . . Opening Faculty Convocation
September 1, Friday* . . . . . Registration
September 4, Monday . . . . . University holiday, offices closed
September 6, Wednesday . . . . . Class work begins
September 8, Friday, 4 p.m. . . . . . End of fee payment period
September 14, Thursday, 4-6 p.m. . . . . . Graduate English examination
September 26, Tuesday . . . . . Last day a course may be dropped without recommendation of instructor
September and October . . . . . Preclassification for Winter Quarter
October 13, Friday . . . . . Diploma slips due for Winter Quarter
October 18, Wednesday . . . . . Thesis due in Thesis Office for initial checking
To be announced . . . . . Educational Testing Service foreign language examinations
October 31, Tuesday . . Last day a course may be dropped without extenuating circumstances
November 1, Wednesday . . . . . Last day for advanced degree final oral examinations
November 3-6, Friday-Monday . . . . . Homecoming—classes dismissed at noon Friday, resume 12:10 p.m. Monday
November 8, Wednesday . . . . . Final deposit of thesis in Thesis Office
November 15, Wednesday . . . . . Examinations begin
November 21, Tuesday . . . . . Examinations end
November 15, 16, 17, and 20, Wednesday-Friday, Monday . . . . . Registration
November 22, Wednesday . . . . . Graduation
November 23-24, Thursday-Friday . . . . . University holidays, offices closed
*Students in residence preceding quarter register during examination week of that quarter

SEPTEMBER						
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OCTOBER						
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NOVEMBER						
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DECEMBER						
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JANUARY						
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21	22	23	24	25	26	27
28	29	30	31			

FEBRUARY					
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18	19	20	21	22	23
25	26	27	28		

WINTER QUARTER 1973

November 28, Tuesday* . . . . . Registration
November 29, Wednesday . . . . . Class work begins
December 1, Friday, 4 p.m. . . . . . End of fee payment period
December 7, Thursday, 4-6 p.m. . . . . . Graduate English examination
December 19, Tuesday . . . . . Last day a course may be dropped without recommendation of instructor
December 22, Friday, 6 p.m. . . . . . Christmas recess begins
December 25-26, Monday-Tuesday . . . . . University holidays, offices closed
December and January . . . . . Preclassification for Spring Quarter
January 1, Monday . . . . . University holiday, offices closed
January 3, Wednesday, 7 a.m. . . . . . Class work resumes
January 12, Friday . . . . . Diploma slips due for Spring Quarter
To be announced . . . . . Educational Testing Service foreign language examinations
January 20, Saturday . . . . . Thesis due in Thesis Office for initial checking
February 2, Friday . . . . Last day a course may be dropped without extenuating circumstances
February 3, Saturday . . . . . Last day for advanced degree final oral examinations
February 10, Saturday . . . . . Final deposit of thesis in Thesis Office
February 19-23, Monday-Friday . . . . . Examination week
February 19-22, Monday-Thursday . . . . . Registration for Spring Quarter
February 24, Saturday . . . . . Graduation
*Students in residence preceding quarter register during examination week of that quarter

SPRING QUARTER 1973

March 2, Friday* . . . . . Registration
March 5, Monday . . . . . Class work begins
March 7, Wednesday, 4 p.m. . . . . End of fee payment period
March 15, Thursday, 4-6 p.m. . . . . Graduate English examination
March 23, Friday . . . . . Last day a course may be dropped without recommendation of instructor
March and April . . . . . Preclassification for Summer Quarter and Fall Quarter
April 13, Friday . . . . . Diploma slips due for Summer Quarter
To be announced . . . . . Educational Testing Service foreign language examinations
April 19, Thursday, 6 p.m. . . . . Easter recess begins
April 21, Saturday . . . . . Thesis due in Thesis Office for initial checking
April 24, Tuesday, 7 a.m. . . . . Class work resumes
May 3-5, Thursday-Saturday (tentative) . . . . . Veishea—classes dismissed at noon Thursday
May 4, Friday . . . . . Last day a course may be dropped without extenuating circumstances
May 5, Saturday . . . . . Last day for advanced degree final oral examinations
May 12, Saturday . . . . . Final deposit of thesis in Thesis Office
May 21-25, Monday-Friday . . . . . Examination week
May 21-22, Monday-Tuesday . . . . . Registration for Summer Quarter
May 26, Saturday . . . . . Graduation
May 28, Monday . . . . . University holiday, offices closed
*Students in residence preceding quarter register during examination week of that quarter

MARCH							APRIL							MAY							JUNE							JULY							AUGUST						
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
				1	2	3	1	2	3	4	5	6	7			1	2	3	4	5						1	2	1	2	3	4	5	6	7				1	2	3	4
4	5	6	7	8	9	10	8	9	10	11	12	13	14	6	7	8	9	10	11	12	3	4	5	6	7	8	9	8	9	10	11	12	13	14	5	6	7	8	9	10	11
11	12	13	14	15	16	17	15	16	17	18	19	20	21	13	14	15	16	17	18	19	10	11	12	13	14	15	16	15	16	17	18	19	20	21	12	13	14	15	16	17	18
18	19	20	21	22	23	24	22	23	24	25	26	27	28	20	21	22	23	24	25	26	17	18	19	20	21	22	23	22	23	24	25	26	27	28	19	20	21	22	23	24	25
25	26	27	28	29	30	31	29	30						27	28	29	30	31			24	25	26	27	28	29	30	29	30	31						26	27	28	29	30	31	

SUMMER QUARTER 1973

June 4, Monday* . . . . . Registration
June 5, Tuesday . . . . . Class work begins
June 6, Wednesday, 4 p.m. . . . . End of fee payment period
June 14, Thursday . . . . . Last day a course may be dropped without recommendation of instructor (First Session)
June 14, Thursday, 4-6 p.m. . . . . Graduate English examination
June 28, Thursday . . . . . Last day a course may be dropped without extenuating circumstances (First Session)
June and July . . . . . Preclassification for Fall Quarter
July 4, Wednesday . . . . . University holiday, offices closed
July 10, Tuesday . . . . . Diploma slips due for Fall Quarter
July 10, Tuesday . . . . . First Session ends
July 11, Wednesday . . . . . Registration for Second Session
July 12, Thursday . . . . . Class work begins
July 12, Thursday . . . . . Thesis due in Thesis Office for initial checking
July 13, Friday, 4 p.m. . . . . End of fee payment period
July 19, Thursday, 4-6 p.m. . . . . Graduate English examination
July 20, Friday . . . . . Last day a course may be dropped without recommendation of instructor (Second Session)
July 26, Thursday . . . . . Last day for advanced degree final oral examinations
August 2, Thursday . . . . . Final deposit of thesis in Thesis Office
August 3, Friday . . . . . Last day a course may be dropped without extenuating circumstances (Second Session)
August 15, Wednesday . . . . . Second Session ends
August 16, Thursday . . . . . Graduation
*Students in residence preceding quarter register during examination week of that quarter

The Graduate Faculty

Administrative Officers

PARKS, W. ROBERT, President; Professor of Political Science
B.A., 1937, Berea; M.A., 1938, Kentucky; Ph.D., 1948, Wisconsin; LL.D., 1966, Berea; L.H.D., 1968, Westmar; LL.D., 1968, Drake

ZAFFARANO, DANIEL J., Vice President for Research; Dean of the Graduate College; Professor of Physics; Distinguished Professor in Sciences and Humanities
B.S., 1939, Case; M.S., 1948, Ph.D., 1949, Indiana

KARAS, GEORGE G., Assistant Dean of the Graduate College; Professor of Psychology
B.A., 1956, DePauw; M.S., 1958, Ph.D., 1959, Purdue

Members of the Graduate Faculty

ABIAN, ALEXANDER, Professor of Mathematics
B.S., 1946, Tehran (Iran); M.S., 1954, Chicago; Ph.D., 1956, Cincinnati

ABRAHAM, WILLIAM H., Professor of Chemical Engineering
B.Ch.E., 1952, Cornell; Ph.D., 1957, Purdue

AMEMIYA, MINORU, Associate Professor of Agronomy
B.S., 1942, California; M.S., 1948, Ph.D., 1950, Ohio State

ANDERSON, ERNEST W., Professor of Aerospace Engineering and Head of the Department; Anson Marston Distinguished Professor in Engineering
B.S., 1926, North Dakota State; M.S., 1928, Ph.D., 1933, Iowa State

ANDERSON, IRVIN C., Professor of Agronomy; Professor of Botany
B.S., 1951, Iowa State; M.S., 1954, Ph.D., 1957, North Carolina State

ANDERSON, JULIA F., Professor, Associate Dean of the College of Home Economics
B.S., 1941, Iowa State; M.S., 1947, Washington

ANDERSON, LLOYD L., Associate Professor of Animal Science
B.S., 1957, Ph.D., 1961, Iowa State

ANDERSON, MARVIN A., Professor of Agronomy; Dean of University Extension and Director of the Cooperative Extension Service
B.S., 1939, M.S., 1949, Ph.D., 1955, Iowa State

ANDERSON, PAUL M., Professor of Electrical Engineering
B.S., 1949, M.S., 1958, Ph.D., 1961, Iowa State

ANDRE, FLOYD, Professor of Entomology; Dean of the College of Agriculture; Director of the Agriculture and Home Economics Experiment Station
B.S., 1931, M.S., 1933, Ph.D., 1936, Iowa State

ANGELICI, ROBERT J., Associate Professor of Chemistry
B.S., 1959, St. Olaf; Ph.D., 1962, Northwestern

APPLEQUIST, JON B., Professor of Biophysics
B.S., 1954, California (Berkeley); Ph.D., 1959, Harvard

APT, LEON J., Associate Professor of History
B.A., 1956, M.A., 1957, Arkansas; Ph.D., 1965, Chicago

ARNOLD, BARRY C., Associate Professor of Mathematics; Associate Professor of Statistics
B.Sc., 1961, McMaster; M.S., 1963, Ph.D., 1965, Stanford

ARNOLD, LIONEL K., Professor of Chemical Engineering
A.B., 1920, Ellsworth; B.S., 1921, M.S., 1926, Ph.D., 1930, Iowa State

ARNRICH, LOTTE, Professor of Food and Nutrition
B.S., 1944, Ph.D., 1952, California

ATKINS, RICHARD E., Professor of Agronomy
B.S., 1941, Kansas State; M.S., 1942, Ph.D., 1948, Iowa State

AUGUSTINE, GRACE M., Professor Emeritus of Institution Management
B.S., 1929, M.A., 1930, Ph.D., 1935, Columbia

AVANT, LLOYD L., Associate Professor of Psychology
B.A., 1957, M.A., 1961, Furman; Ph.D., 1966, Kansas State

BACHMANN, ROGER W., Associate Professor of Fisheries Biology
B.S., 1956, Ph.D., 1962, Michigan; M.S., 1958, Idaho

BAGLIN, JOHN E., Assistant Professor of Physics
B.S., 1957, M.S., 1959, Ph.D., 1964, Melbourne (Australia)

BALLOUN, STANLEY L., Professor of Animal Science
B.S., 1930, Ph.D., 1952, Iowa State

BANCROFT, THEODORE A., Professor of Statistics and Head of the Department; Director of the Statistical Laboratory
A.B., 1927, Florida; A.M., 1934, Michigan; Ph.D., 1943, Iowa State

BARNES, RICHARD G., Professor of Physics
B.A., 1948, Wisconsin; M.A., 1949, Dartmouth; Ph.D., 1952, Harvard

BARNES, WILFRED E., Professor of Mathematics and Head of the Department
S.B., 1949, S.M., 1950, Chicago; Ph.D., 1954, British Columbia (Canada)

BARTON, THOMAS A., Professor of Landscape Architecture and Head of the Department
B.S., 1941, M.L.A., 1960, Iowa State

BARTZ, WAYNE H., Professor of Psychology
B.A., 1960, M.A., 1961, Western Michigan; Ph.D., 1963, Purdue

BATH, JOHN A., Professor of Psychology; Professor of Education
A.B., 1932, Peru State; M.A., 1933, Ph.D., 1942, Nebraska

BAUMANN, E. ROBERT, Professor of Civil Engineering
B.S.E., 1944, Michigan; B.S., 1945, M.S., 1947, Ph.D., 1954, Illinois

BAUTISTA, RENATO G., Assistant Professor of Chemical Engineering
B.S., 1955, Santo Tomas (the Philippines); S.M., 1957, Massachusetts Institute of Technology; Ph.D., 1961, Wisconsin

BEAL, GEORGE M., Professor of Sociology and Chairman of the Department of Sociology and Anthropology
B.S., 1943, M.S., 1947, Ph.D., 1953, Iowa State

BEER, CRAIG E., Associate Professor of Agricultural Engineering
B.S., 1950, M.S., 1957, Ph.D., 1962, Iowa State

BENEKE, RAYMOND R., Professor of Economics
B.S., 1940, M.S., 1946, Iowa State; Ph.D., 1949, Minnesota

BENSEND, DWIGHT W., Professor of Forestry
B.S., 1937, Ph.D., 1942, Minnesota

BENSON, DONALD R., Professor of English
A.B., 1949, Kansas City; M.A., 1951, Colgate; Ph.D., 1959, Kansas

BERARD, MICHAEL F., Assistant Professor of Ceramic Engineering; Associate Engineer, Institute for Atomic Research
B.S., 1960, M.S., 1962, Ph.D., 1968, Iowa State

BERESFORD, HOBART, Professor Emeritus of Agricultural Engineering
B.S., 1924, A.E., 1941, Iowa State

BEVERIDGE, ELIZABETH, Professor of Family Environment
B.S., 1929, Colorado State; M.S., 1934, Iowa State

BIGGS, DONALD L., Professor of Geology
B.A., 1949, M.A., 1951, Missouri; Ph.D., 1957, Illinois

BIRD, EMERSON W., Professor of Food Technology; Professor of Biochemistry
B.S., 1923, Pennsylvania State; Ph.D., 1929, Iowa State

BLACK, CHARLES A., Professor of Agronomy; Charles F. Curtiss Distinguished Professor in Agriculture
B.S., 1937, Colorado State; M.S., 1938, Ph.D., 1942, Iowa State

BLACK, HENRY M., Professor of Mechanical Engineering and Head of the Department
B.S., 1929, Iowa State; S.M., 1934, Harvard

BOAST, WARREN B., Professor of Electrical Engineering and Head of the Department
B.S., 1933, M.S., 1934, Kansas; Ph.D., 1936, Iowa State

BOCKHOP, CLARENCE W., Professor of Agricultural Engineering and Head of the Department
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SUN, CHANG-TSAN, Associate Professor of Engineering Mechanics
B.S., 1953, Taiwan; M.S., 1960, Stevens; Dr. Eng., 1964, Yale

SWIFT, CURRAN S., Assistant Professor of Electrical Engineering
B.S., 1962, M.S., 1964, Ph.D., 1968, Iowa State

TANNEHILL, JOHN C., Assistant Professor of Aerospace Engineering
B.S., 1965, M.S., 1967, Ph.D., 1969, Iowa State

THOMAS, JAMES A., Assistant Professor of Biochemistry and Biophysics
B.A., 1960, St. Olaf; M.S., 1963, Ph.D., 1967, Wisconsin

THOMAS, REX A., Assistant Professor of Computer Science; Assistant Professor of Education
B.A., 1955, Iowa; M.A., 1961, Northern Iowa; Ph.D., 1970, Iowa State

THOMAS, ROBERT W., Associate Professor of Economics
B.A., 1948, Iowa; M.A., 1951, New Mexico; Ph.D., 1962, Iowa State

THOMAS, VIRGINIA F., Associate Professor of Home Economics Education
B.S., 1936, West Virginia State; M.S., 1949, West Virginia; Ph.D., 1965, Ohio State

THOMSON, GEORGE W., Professor of Forestry
B.S., 1943, M.S., 1947, Ph.D., 1956, Iowa State

TO, CHUEN-MO, Assistant Professor of Cell Biology
B.S., 1960, Taiwan Normal; M.A., 1962, Clark (Worcester); Ph.D., 1968, Kansas State

TONDRA, RICHARD J., Assistant Professor of Mathematics
B.S., 1965, Notre Dame; M.S., 1966, Ph.D., 1968, Michigan State

TOPEL, DAVID G., Associate Professor of Animal Science; Associate Professor of Food Technology
B.S., 1960, Wisconsin; M.S., 1962, Kansas State; Ph.D., 1965, Michigan State

TOWNSEND, CHARLES L., Associate Professor of Electrical Engineering
B.S., 1953, Oklahoma; M.S., 1957, Ph.D., 1963, Iowa State

TRISKA, C. J., Professor of Electrical Engineering
B.S., 1950, M.S., 1956, Ph.D., 1961, Iowa State

TROEH, FREDERICK R., Associate Professor of Agronomy
B.S., 1951, M.S., 1952, Idaho; Ph.D., 1963, Cornell

TSAI, FRANK Y., Assistant Professor of Engineering Mechanics
B.S., 1955, National Taiwan; M.S., 1960, Ph.D., 1968, Minnesota

ULRICHSON, DEAN L., Assistant Professor of Chemical Engineering; Assistant Professor of Computer Science
B.S., 1962, Nebraska; M.S., 1963, Illinois; Ph.D., 1970, Iowa State

VAN DE WETERING, HYLKE, Associate Professor of Economics
B.Sc., 1959, M.A., 1961, McGill (Canada); Ph.D., 1964, Iowa State

VAN GELDER, GARY A., Associate Professor of Veterinary Pathology, Veterinary Medical Diagnostic Laboratory and Biomedical Engineering
D.V.M., 1965, M.S., 1967, Ph.D., 1969, Iowa State

VILES, JOSEPH M., Assistant Professor of Zoology
B.A., 1965, Rice; M.S., 1968, Ph.D., 1969, Tulane

VOLKER, ROGER P., Assistant Professor of Education
B.S., 1956, M.S., 1963, Ph.D., 1970, Iowa State

VOSS, REGIS D., Professor of Agronomy
B.S., 1952, M.S., 1960, Ph.D., 1962, Iowa State

WEDMAN, E. EDWARD, Professor of Veterinary Microbiology and Preventive Medicine; Associate Director, Veterinary Medical Research Institute
D.V.M., 1945, Kansas State; M.P.H., 1956, Ph.D., 1964, Minnesota

WEIGLE, JACK L., Associate Professor of Horticulture
B.S., 1950, M.S., 1954, Purdue; Ph.D., 1956, Michigan State

WELLS, HELEN L., Associate Professor of Family Environment
B.S.H.E., 1943, M.S., 1952, B.A., 1961, Arkansas; Ph.D., 1958, Cornell

WELTHA, DAVID A., Assistant Professor of Family Environment
B.A., 1954, St. Olaf; M.A., 1957, Northern Iowa; Ph.D., 1969, Iowa State

WESSEL, ROBERT I., Associate Professor of Political Science
B.S., 1953, M.S., 1961, Iowa State

WHITAKER, JAMES W., Associate Professor of History
B.A., 1960, Oberlin; M.S., 1962, Ph.D., 1965, Wisconsin

WHITE, BERNARD J., Assistant Professor of Biochemistry
B.S., 1958, Portland; M.A., 1961, Ph.D., 1963, Oregon

WIENER, MERLE O., Associate Professor of Education
B.S., 1938, Northern Iowa; M.S., 1950, Iowa State

WIJTING, JAN P., Assistant Professor of Psychology
B.A., 1966, Bradley; Ph.D., 1970, Bowling Green

WILCOX, LESLIE D., Assistant Professor of Sociology
B.A., 1958, Seattle Pacific; M.S., 1965, Ph.D., 1968, Colorado State

WILDMAN, RUTH B., Assistant Professor of Botany
A.B., 1946, Mount Holyoke; M.S., 1947, Illinois; Ph.D., 1969, Iowa State

WILLETT, RICHARD M., Associate Professor of Electrical Engineering
B.A., 1951, Iowa; M.S., 1956, Ph.D., 1966, Iowa State

WILLRICH, TED L., Professor of Agricultural Engineering
B.S., 1949, Ph.D., 1961, Iowa State; M.S., 1952, Oklahoma A and M

WILSON, FRANK L., Assistant Professor of Political Science
B.A., 1964, M.A., 1965, Ph.D., 1969, California (Los Angeles)

WILT, ALAN F., Assistant Professor of History
B.A., 1959, DePauw; M.A., 1960, Ph.D., 1969, Michigan

WING, LARRY D., Assistant Professor of Zoology and Entomology
B.S., 1958, M.S., 1963, Ph.D., 1970, Idaho

WISNER, ROBERT N., Assistant Professor of Economics
B.S., 1962, M.S., 1964, Michigan State; Ph.D., 1967, Tennessee

WOHN, FRED K., Assistant Professor of Physics
B.S., 1962, Louisiana State; M.S., 1964, Ph.D., 1967, Indiana

WOOTEN, JEAN W., Assistant Professor of Botany
B.S., 1948, North Georgia; M.S., 1966, Ph.D., 1968, Florida State

WRIGHT, CHARLES T., JR., Assistant Professor of Computer Science; Senior Systems Analyst, Institute for Atomic Research
B.A., 1963, M.A., 1964, Southern Illinois; Ph.D., 1970, Iowa State

YARBROUGH, J. PAUL, Assistant Professor of Journalism and Mass Communication; Assistant Professor of Sociology
B.S., 1960, Georgia; M.S., 1966, Ph.D., 1968, Iowa State

YOESTING, DEAN R., Assistant Professor of Sociology; Assistant Professor of Forestry
B.S., 1961, M.S., 1963, Ohio State; Ph.D., 1967, Wisconsin

YOUNG, JAMES C., Assistant Professor of Civil Engineering
B.S., 1963, M.S., 1964, New Mexico State; Ph.D., 1968, Stanford

ZARING, PHILIP B., Assistant Professor of History
B.A., 1955, Indiana; M.A., 1959, Ph.D., 1966, Yale

ZBARACKI, RICHARD J., Associate Professor of English; Associate Professor of Education
B.A., 1953, St. Thomas; M.A., 1954, Northwestern; Ph.D., 1970, Nebraska

ZIMMERMAN, DEAN R., Associate Professor of Animal Science
B.S., 1954, Ph.D., 1960, Iowa State

ZIMMERMAN, KAREN W., Assistant Professor of Home Economics Education
B.S., 1964, M.S., 1968, Ph.D., 1970, Iowa State

ZINGG, ROY J., Associate Professor of Electrical Engineering; Associate Professor of Computer Science
B.S., 1958, M.S., 1961, Ph.D., 1968, Iowa State

ZOBER, MARTIN, Professor of Industrial Administration
B.A., 1940, M.Litt., 1943, Ph.D., 1950, Pittsburgh

Graduate College

Iowa State University has offered opportunities for graduate work to qualified students since the founding of the institution. The first advanced degree was conferred in 1877. In early years, the work of graduate students was in immediate charge of the departments concerned, under the supervision of the general faculty. Later, each of the faculties of the colleges of Agriculture, Engineering, Home Economics, Science, and Veterinary Medicine assumed control of graduate work. In 1913, a distinct graduate faculty was organized, and an executive graduate committee was appointed. In 1915, the graduate faculty held its first meeting, and in 1916 it granted the first degree Doctor of Philosophy.

The graduate faculty consists of the president, the dean of the Graduate College, the vice president for academic affairs, deans of the six colleges, the director of the library, the dean of admissions and records, heads of departments offering graduate work, and members of the faculty who are elected to membership in recognition of accomplishments in their respective disciplines.

The Graduate College administers advanced study and degree programs in most fields of study offered by the University. Most of the graduate programs offered are research-oriented and lead to the degrees Master of Science and Doctor of Philosophy. In certain fields the degree Master of Arts and the degree Master of Science without thesis are also available.

For those persons interested in advanced study directed more particularly toward meeting vocational or professional objectives, the degrees Master of Architecture, Master of Education, Master of Engineering, Master of Forestry, and Master of Landscape Architecture are offered.

GRADUATE APPOINTMENTS

Graduate assistantships, industrial fellowships, and certain special research grants have been established at Iowa State University for the encouragement of graduate work and the promotion of research. Such appointments and research opportunities are available through the various departments of instruction, the Agriculture and Home Economics Experiment Station, the Engineering Research Institute, the Home Economics Research Institute, the Sciences and Humanities Research Institute, the Statistical Laboratory, the Computation Center, the Institute for Atomic Research, and the Veterinary Medical Research Institute.

Graduate assistantships permit the holder to enroll for 11 credits per quarter. Recipients of these assistantships are exempt from payment of other fees except for $120 per quarter. A graduate assistant is expected to give half-time service to the teaching or research projects of his department. These appointments are open to students who have graduated from approved colleges in the highest quartile of their respective classes and who present the requisite undergraduate or graduate preparation. Further information may be obtained by writing to the department head concerned or to the dean of the Graduate College.

Fellowships and training grants supported by agencies of the federal government, as well as University-supported fellowships are available. Applicants for these awards must present evidence of superior scholarship. Further information may be secured by writing to the dean of the Graduate College.

The satisfactory completion of one appointment will ordinarily make a student eligible for reappointment.

POST DOCTORAL STUDY

Opportunities are provided for postdoctoral study through the extensive research programs of the University. Inquiries should be directed to the appropriate institute or to the dean of the Graduate College.

GRADUATE STUDY BY MEMBERS OF THE STAFF

Any member of the research, instructional, or extension staffs of the rank of instructor, associate, or junior scientist, subject to the approval of the head of his department or section, may carry not more than 5 credits of graduate work per quarter, provided such does not interfere with his other duties. This privilege may be extended to members of the research, instructional, or extension staffs of the rank of assistant professor upon approval of the college dean concerned and the dean of the Graduate College.

Staff members holding the rank of professor or associate professor cannot become candidates for degrees from this institution.

ADMISSION

A prospective student is invited to correspond with the head of the department in which he wishes to study for information concerning graduate study in that academic discipline.

Application blanks are available from the Office of Admissions, 7 Beardshear Hall. These blanks, together with official transcripts and statement of quartile rank, should be forwarded to the Office of Admissions at least one month prior to the opening of the quarter when the student wishes to matriculate. An application fee of $10 is charged each applicant (except graduates of Iowa State University) formally applying for admission to the Graduate College.

Unrestricted Admission. An applicant who is a graduate of an institution in the United States whose requirements for the bachelor's degree are substantially equivalent to those at Iowa State University, and who ranks in the upper one-half of his class, may be admitted to the Graduate College, if recommended by the department head and approved by the dean of the Graduate College. Admission does not constitute acceptance as a candidate for a degree.

Admission to the Graduate College may not be granted to a graduate of an institution in the United States which is not accredited by a recognized regional association.

Restricted Admission. An applicant who is a graduate of an accredited university in the United States, but who does not rank in the upper one-half of his class, may be granted restricted admission if such consideration seems justified. This will require the recommendation by the department head and approval by the graduate dean.

Transfer from restricted admission to unrestricted admission requires recommendation of the major professor and approval by the graduate dean.

Graduates of recognized universities located outside the United States may be granted restricted admission only.

Medical Examination. Upon entering Iowa State University, each graduate student is required to have a physical examination which must include a tuberculin test and/or chest x-ray taken within the past year. Students accepted for admission will be sent forms to be completed by a personal physician who should return them promptly to the University Hospital. Registration will not be permitted until this requirement has been met.

Foreign students are required to carry adequate health and accident insurance while in residence.

Graduate Record Examination. No uniform examination is currently required of all applicants for admission.

English Requirement. All graduate students, except those who have met the requirement as undergraduates at Iowa State University within the last two years and graduate students admitted on a nondegree basis are required to pass a qualifying examination in English. It is expected that this requirement will be met during the first quarter or summer term of residence.

Foreign students take a special examination which is administered by the Department of English in cooperation with the Office of Foreign Student and Visitor Services.

REGISTRATION

Planning Graduate Study. Scholastic competence, independence and maturity of thought should have dominance over other objectives of graduate study. The student must accept responsibility for his own education and should recognize that excessive emphasis on course work will not leave time to explore and master aspects of learning which will give him con-

fidence in his own judgments. As soon as possible, in conference with the head of his department, the student should select his major professor and advisory committee and in consultation with them outline his program of study.

Residence Registration. Classification in courses carrying full graduate credit is limited to a maximum of 15 credits per quarter. The maximum, if part of the work is supporting (not for graduate credit), is 16 credits. Schedules for graduate assistants are limited to a maximum of 11 credits; for full-time staff members, to 5 credits.

Graduate students (even though course and residence requirements have been met) must register in any quarter in which the facilities of the institution or staff time are being used in preparation of thesis or in preparation for examination. The number of credits under these circumstances shall be consonant with the amount of work done, laboratory facilities used, and staff direction involved.

Interim Registration. Registration for special work between quarters and during certain vacation periods cannot exceed 1 credit for each week that the student is in residence. The fee is $29 per credit for residents and $50 per credit for nonresidents.

"In Absentia" Registration. Graduate work by correspondence is not permitted, nor is it accepted in transfer. In exceptional cases, the Graduate Faculty Cabinet may authorize registration *in absentia.* Generally such registration is restricted to thesis preparation after completion of research or for research under special conditions. The total credit thus obtained cannot be used to reduce residence requirements.

Extension and Off-campus Registration. Classes away from the campus in some areas of engineering and education are taught by members of the University graduate staff. Only limited credit earned in such classes can be applied toward a graduate degree. Such courses cannot be used to meet the residence requirement.

Auditing. Courses may be audited upon recommendation of the student's major professor. Each audited course will reduce the permitted credit load by one, but fees will be assessed on the basis of catalog credit.

Graduate Credit for Seniors. Under special circumstances, a department head may request from the graduate dean permission to classify a senior student in certain graduate courses if he is within 6 credits of fulfilling requirements for the bachelor's degree. Then, after the student has received his bachelor's degree and has been registered in the Graduate College, the chairman of his graduate committee may request by letter that the credits so received be applied toward an advanced degree.

Special Regulations for Students in Veterinary Medicine. Specially qualified graduates in scientific curricula, when the request has been approved by the dean of Veterinary Medicine and the dean of the Graduate College, may pursue work coincidentally toward the degrees Master of Science and Doctor of Veterinary Medicine. The major graduate work of such students must be completed in courses not required in the undergraduate curriculum in Veterinary Medicine. A student taking advantage of this opportunity will classify with both the dean of Veterinary Medicine and the dean of the Graduate College.

DEGREE REQUIREMENTS

A *Guide to Graduate College Procedures* is available in the Office of the Graduate Dean, 222 Beardshear Hall. Each new graduate student is urged to secure a copy.

Probation. To remain in good standing, a student must maintain an average of B in all coursework (exclusive of research) taken in the Graduate College. The Graduate Dean may place a student on probation for failure to meet scholastic or other requirements. Removal from probation is accomplished upon specific recommendation from the student's major professor to the Graduate Dean. Students will not be admitted to candidacy while on probation. Generally registration beyond the third quarter will be refused to a student whose quality of work is unsatisfactory.

Time Limit. It is expected that work for the master's degree shall be completed within a term of three years or five summer quarters; for the doctorate, work shall be completed

within a term of five years. Only in exceptional cases, upon recommendation of a student's advisory committee and with approval by the Graduate Faculty Cabinet, is credit allowed for courses taken over a period of more than five years.

Master of Science and Master of Arts

A student becomes eligible for candidacy after completing one quarter's work with a "B" average. General requirements for the degree are as follows:

Appointment of the Student's Advisory Committee. Following enrollment in the Graduate College and as soon as practicable thereafter, the department head shall recommend to the dean of the Graduate College, a committee of the graduate faculty to be in charge of the student's work. This committee shall consist of at least three members of the graduate faculty, one of whom must come from a different department. An associate member of the graduate faculty may serve as major professor for a master's degree candidate.

Program of Study. A program of study should be developed in consultation with the student's committee. This should be submitted for approval by the end of the second quarter in residence.

Residence. Three quarters, or a minimum of 30 weeks of full-time graduate study, must be spent in residence at Iowa State University. In some programs, arrangements have been made whereby residence credit earned at specific sister institutions may be accepted as residence credit on this campus.

Credits. At least 45 credits of acceptable graduate work must be completed, not less than 36 of which must be taken in this institution.

Any transfer of credits from another institution must be recommended in the program of study by the student's advisory committee. Transfer of graduate credit will be approved only if it is of "B" grade or better.

Major and Minor. The exact number of credits in major and minor fields is not prescribed. To obtain the specialization which is considered essential for an advanced degree, approximately two-thirds of the work should be devoted to the major field, but this is not necessarily restricted to one department.

A graduate student may not change from one major to another without written permission from the head of each department and approval from the dean of the Graduate College.

Foreign Languages. There is no uniform requirement for the Graduate College. Please see the departmental descriptions in this catalog for details.

For those departments wishing to utilize them and for students interested in transferring a foreign language test score elsewhere, the University offers the standardized examinations provided by Educational Testing Service.

For students whose native language is not English, the ability to communicate adequately in English (certified by the Department of English) may be acceptable as a substitution for the reading knowledge of one foreign language. This option will apply only when specifically recommended by the student's advisory committee.

The foreign language requirement, where applicable, may not be met in the quarter in which the student will receive his degree.

Application for Graduation. Application for graduation must be made by midterm of the quarter preceding the quarter in which the student expects to receive the degree. This requires the presentation of an approved diploma slip to the Office of the Graduate Dean.

Thesis. A thesis is required in all areas in which the M.S. or M.A. is granted, except where specific provision is made for a nonthesis degree program. Joint authorship is not permitted. Copies of the completed thesis must be in the hands of the examining committee and the Thesis Office for approval two weeks prior to the date fixed for the final examination. After the final examination, two unbound approved copies of the thesis shall be deposited with the Thesis Office, University Library. These copies of the thesis must be deposited not less than two weeks prior to commencement. A charge of $25 will be made to cover library costs and title publication in the *Iowa State Journal of Science.*

The student should consult *The Graduate College Thesis Manual,* prepared for the use of students in the Graduate College, before arranging for the typing of his thesis.

Final Examination. After all other requirements have been met, the final examination shall be taken on all graduate work, including the thesis where applicable. It will ordinarily be oral, but may be written in whole or in part, as determined by the committee in charge.

Graduation Approval Slip. These slips are prepared by the Office of Student Records about two weeks prior to the end of a quarter. Candidates wishing to secure this form at any earlier date should file a request with the Office of the Graduate Dean at least three days prior to the time the form is needed.

Master of Science and Master of Arts—Nonthesis

In certain authorized departments where research specialization does not best meet the professional needs of the student, a nonthesis degree program may be undertaken. This will require satisfactory completion of at least 45 quarter hours of acceptable credits (not including research credit) and satisfactory completion of a comprehensive examination. Detailed requirements may vary with fields. Reference should be made to the departmental descriptions in this catalog.

Master of Architecture

For the degree Master of Architecture, a minimum of 90 credits beyond the degree Bachelor of Arts or 45 credits beyond the degree Bachelor of Architecture is required.

Master of Education

For the degree Master of Education, a minimum of 52 credits will be required, provided all credits are in graduate level courses. A minimum of 15 credits must be earned in course work outside the major. No foreign language is required. A field study is written in lieu of a thesis.

Master of Engineering

The academic standards and the general level of attainment are the same for the Master of Engineering and Master of Science degrees. Master of Engineering programs are intended to be more flexible in their educational objectives, and they are offered to meet the expanding needs for off-campus graduate engineering programs at locations with adequate library and laboratory facilities, and for special situations of professionally oriented programs on campus.

General requirements for the degree Master of Engineering are the same as those for the degree Master of Science. No foreign language is required. Upon recommendation of the student's committee, the thesis requirement may be waived. Choice of this option requires the completion of an additional 7 credits of acceptable graduate work.

Of the minimum credit requirement of 45, 36 credits must be received from Iowa State University. At least 12 credits must be earned in residence at Iowa State University during one quarter or two summer terms, not necessarily consecutive sessions.

Master of Forestry

The degree Master of Forestry is designed to provide advanced educational opportunities for the student with objectives that require graduate study, but who intends to enter the forestry profession as a practitioner rather than as a researcher or teacher. Primary emphasis is on professional development on a broad plane for an administrative career but with freedom for some concentration within this framework.

The Master of Forestry degree is a nonthesis program which calls for completion of 52 credits of acceptable graduate work of which at least 35 credits must be at the 500- or 600-level. Thirty-six credits are required in residence at Iowa State University. The foreign language requirement may be waived upon the recommendation of the department head.

Master of Landscape Architecture

General requirements are the same as those for the degree Master of Science with the exception that a student has the option of presenting a terminal problem in lieu of a thesis. The foreign language requirement may be waived upon recommendation of the department head.

Doctor of Philosophy

The degree Doctor of Philosophy is strongly research oriented. The primary requirements for the degree are: (1) high attainment and proficiency of the candidate in his chosen field, (2) development of a dissertation which shall be a significant contribution to knowledge and which shall show power of independent and creative thought and work, and (3) successful passing of detailed examinations over the field of the candidate's major work, with a satisfactory showing of his preparation in related and minor courses.

Appointment of the Student's Advisory Committee. Following enrollment in the Graduate College, and as soon as practicable thereafter, the department head shall recommend to the dean of the Graduate College a committee of the graduate faculty to be in charge of the student's graduate program. This committee shall consist of the following: at least five members of the graduate faculty—two of whom must come from outside the major discipline, with one of these from a different department. An associate member of the graduate faculty may not serve as major professor of a doctoral program.

Program of Study. A program of study should be developed in consultation with the student's committee. This should be submitted for approval by the end of the third quarter in residence.

Residence. A minimum of three years shall be spent in full-time graduate study, at least half of which is to be in residence at Iowa State University. At least three quarters of resident study must be during the academic year. To satisfy any one-year residence requirement, at least 36 credits must be earned. Any transfer of graduate credit from another institution must be recommended in the program of study by the student's advisory committee. Transfer of graduate credit will be approved only if it is of "B" grade or better.

Major and Minor. To avoid overspecialization, a significant body of pertinent course work must be taken outside of the major field. The work outside the major field should amount to approximately 18 hours of applicable graduate credit as required by the student's committee.

The major field is equivalent to the major department except for: (1) established interdisciplinary majors and (2) majors within departments which may be approved by the Graduate Faculty Cabinet.

Foreign Languages. There are no uniform requirements for the Graduate College. Please see the departmental descriptions in this catalog for details.

For those departments wishing to use them and for students interested in transferring a foreign language test score elsewhere, the University offers the standardized examinations provided by the Educational Testing Service.

For students whose native language is not English, the ability to communicate adequately in English (certified by the Department of English) may be acceptable as a substitution for the reading knowledge of one foreign language. This option will apply only when specifically recommended by the student's advisory committee.

The foreign language requirement, where applicable, must be met before the preliminary examination is held.

Preliminary Examination. The student must pass satisfactorily a preliminary examination before he is granted advancement to candidacy for the degree. The examination is usually both written and oral, unless otherwise specifically recommended by the committee. The preliminary examination must be passed at least three quarters before the final examination. Exceptions to this rule will be made only upon special recommendation of the student's committee and approval of the Graduate Faculty Cabinet. In no case may the final examination be given less than six months from the time of the preliminary examination.

Diploma Slip. A diploma slip must be filled out and returned by midterm of the quarter preceding the quarter in which the student expects to receive the degree.

Dissertation. A doctoral dissertation shall be completed on some topic connected with the major subject. To be acceptable it must constitute a significant contribution to knowledge. Joint authorship is not permitted.

Copies of the completed dissertation must be in the hands of the examining committee and the Thesis Office for approval two weeks prior to the date fixed for the final examination. After the examination, and at least two weeks prior to commencement, two complete and approved copies of the dissertation shall be deposited with the Thesis Office, University Library.

At the same time the dissertation is deposited, two typewritten copies of an abstract which meet the requirements as set forth in *The Graduate College Thesis Manual* must also be filed with the Thesis Office, University Library. A charge of $50 will be made to cover library costs, microfilming of the dissertation, and publication of a 600-word abstract in *Dissertation Abstracts.* The abstract should cover the entire dissertation and should not be considered as excluding publication of a journal article.

Final Examination. A final examination shall be taken on all graduate work, including dissertation. This examination shall be conducted by the student's committee with such other members of the faculty as may be designated by the dean of the Graduate College. It will be written or oral, or both, as determined by the committee.

Graduation Approval Slip. These slips are prepared by the Office of Student Records about two weeks prior to the end of a quarter. Candidates wishing to secure this form at any earlier date should file a request with the Office of the Graduate Dean at least three days prior to the time the form is needed.

Fees and Expenses

All fees and expenses listed in this catalog were effective as of September 1, 1970. They are subject to change at any time thereafter without notice.

A registration fee is charged all students of the University. A full registration fee covers laboratory fees, hospital service, use of the Library, membership in the Memorial Union, and a number of student activities. The activity fee is optional for graduate students and students on light classification. Students who are not residents of Iowa pay an additional tuition fee each quarter. This is assessed in accordance with regulations of the State Board of Regents, found in this catalog under *Admissions*.

FEE SCHEDULE

	Iowa Resident	Nonresident
Per quarter	$235	$410
Per summer session	118	205
Light classification, fee per hour	29	50
Fee reduction	120	120
0 or no credit course, fee per course	75	150
R credit course, fee per course	29	50
Reinstatement after registration cancellation	10	10

Audit—Same as light classification
Off-campus—Same as light classification
In absentia—Same as light classification

Interim Fee

	Iowa Resident	Nonresident
1 hour	$18	$32
2 hours	36	64

	Iowa Resident	Nonresident
Lakeside Laboratory	$100	$100
Driver education	25	25
Special women's education	20	20
Change of classification	1	1

REGISTRATION FEE FOR STUDENTS WITH FEE REDUCTIONS

For students with fee reductions, the registration fee for each of the fall, winter, and spring quarters is $120. For either term of the summer quarter, the fee is $60.

This fee covers laboratory fees, hospital service, use of the Library, and membership in the Memorial Union. An activity fee is optional.

APPLICATION FEE

A fee of $10 must accompany the application for admission and is nonrefundable except in the case of residents of Iowa who are denied admission. This fee will not apply to graduates of Iowa State University, nondegree candidates, or workshop applicants.

LATE REGISTRATION

A fee of $5 for the first day and $1 per day thereafter is charged to those who do not complete registration during the regular registration period. Maximum charge for late registration is $10.

ACTIVITY FEE

Students whose payments do not include the activity fee may pay $9 per quarter and receive admission to concerts, lectures, and debates and subscriptions to several student publications. An additional charge is made for admission to football and basketball games.

THESIS AND DISSERTATION FEES

A charge of $25 will be assessed masters' candidates to cover library costs and title publication in the Iowa State Journal of Science.

A charge of $50 will be assessed doctoral candidates to cover library costs, microfilming of the dissertation and publication of a 600-word abstract in *Dissertation Abstracts*. An additional charge will be made for abstracts which exceed 600 words.

REFUNDS

Refunds are made on the unused portions of fees for registration, room, and board under the following policy:

Registration fee and room rental—Ten percent is deducted for each week or part of a week that the student is enrolled, but no refund is granted if the student is in the University beyond the fifth week of the quarter. In each summer session, 20 percent is deducted for each week or part of a week, with no refund after the third week.

Board charges—Ten percent is deducted for each week or portion of a week that the student is enrolled in the University.

Each quarter begins on the registration day immediately preceding the opening of classes and continues through the day previous to graduation day.

GRADUATE STUDENT HOUSING

The University provides housing facilities for approximately 1,350 married students, 272 single graduate men and 118 single graduate women. Other students live in private rooms and apartments in Ames or nearby communities.

Admission to the University is required prior to obtaining University housing. Students admitted to the University will receive from the University Admissions Office, a form to be used to request a housing application. This form must be returned promptly to the Admissions Office for verification of admission information and for information about housing needs. If University housing is indicated, referral will be made to the Residence Office from which contract forms and information will be sent to the student.

A $25 deposit is required at the time a room contract is completed for accommodations in the residence halls, when an application card is completed for a married student apartment operated by the University or when a lease is signed with an owner for private off-campus housing.

Graduate Residence Hall

Buchanan Hall provides housing in 174 single rooms and 108 double rooms for unmarried graduate students. A suite-type room plan provides a semi-private bath shared by the occupants of two single rooms or two double rooms.

The room rate as of September 1970 is $130.00 per quarter in a double room or $170.00 per quarter in a single room. A meal ticket for Linden Hall may be purchased for $178.00 per quarter.

Married Student Housing

The University provides for student families 668 barracks-type apartments in Pammel Court, 196 permanent apartments in Hawthorn Court and 500 permanent apartments in University Village. Rates for these married student apartments as of September 1970 are $40.00

per month in Pammel Court, $85.00 per month in Hawthorn Court and $100.00 per month in University Village.

A list of off-campus apartments for married students may be seen at the University Married Housing Office.

Off-Campus Housing For Single Students

A list of off-campus rooms and apartments may be seen at the Single Off-Campus Housing Office, 1210 Friley Hall.

Departments of Instruction

After the title of each course are two numbers in parentheses. The first indicates the number of lectures and recitations a week and the second the number of hours of laboratory a week. For example, a course title followed by (1-3) is a course with one lecture or one recitation and three hours of laboratory a week.

At the end of the first line of each course description will be found one or more of the following letters: F. W. S. SS., indicating which of the four quarters—fall, winter, spring, summer session—of the academic year the course is offered. Alt. is the abbreviation for alternate. "Alt. W, offered 1972" identifies courses to be available during Winter Quarter of 1971-72. The abbreviation Yr. is used to designate a sequence of three courses taught fall, winter, and spring, respectively. If there is sufficient demand, courses may be offered more frequently than announced.

AEROSPACE ENGINEERING

Ernest W. Anderson, Ph.D., Head of Department

The Graduate Faculty

Members: E.W. Anderson; C.T. Hsu

Associate Members: D.A. Anderson; J.C. Glaser; J.D. Iversen; F.H. Maillie; M.L. Millett, Jr.; L.L. Northup; B.L. Pierson; L.K. Severside; J.C. Tannehill

The department offers work for the degrees Master of Engineering and Master of Science with major in aerospace engineering, and minor work to students taking major work in other departments. Work may be taken for the degree Doctor of Philosophy as a divided major with other departments offering work in related fields for this degree. No foreign language is required for the degrees Master of Engineering, Master of Science, and Doctor of Philosophy. However, the completion of a minimum of 9 credits of additional course work not directly related to the major is required for the degree Doctor of Philosophy. These courses are intended for the cultural enrichment of the student and are subject to the approval of the student's advisory committee.

Prerequisite to major graduate work is the completion of a curriculum substantially equivalent to that required of undergraduate students in aerospace engineering at this institution.

COURSES FOR GRADUATE STUDENTS, minor only

309. REACTION PROPULSION I.
(3-0) Cr. 3. S.
Prerequisite: M.E. 321.
One-dimensional gas-dynamics and applications to nozzles, ducts, and diffusers.

320. STRESS ANALYSIS AND MATERIALS.
(3-0) Cr. 3. W.
Prerequisite: E.M. 325, Met. 231.
Properties of materials used in flight vehicles, objectives of design, analysis of elementary structures.

321. STRUCTURAL ANALYSIS.
(3-0) Cr. 3. S.
Prerequisite: 320.
Use of energy methods and matrices in the calculation of deflections of structures of flight vehicles and in the analysis of statically indeterminate structures of flight vehicles. Analysis of webs in shear.

343. STABILITY AND CONTROL I.
(3-0) Cr. 3. F.
Prerequisite: 246, Math. 321, E.M. 345.
Static stability and control of flight vehicles. Rigid body equations of motion.

344. STABILITY AND CONTROL II.
(3-0) Cr. 3. W.
Prerequisite: 343, E.M. 346.
Dynamic stability and control of flight vehicles.

352. FLIGHT MECHANICS I.
(3-0) Cr. 3. S.
Prerequisite: Math. 321, E.M. 345.
Introduction to space mechanics. The two-body problem. Keplerian motion. Coordinate systems.

411. **REACTION PROPULSION II.**
(3-0) Cr. 3. F.
Prerequisite: 309.
Turbofan, turbojet, turboprop, ramjet, and rocket propulsion system principles.

413. **REACTION PROPULSION III.**
(3-0) Cr. 3. W.
Prerequisite: 411.
Combustion in rocket engines, solid rocket fuels, hardware needs for liquid fuel rockets, nuclear and ion propulsion devices.

415. **REACTION PROPULSION IV.**
(3-0) Cr. 3. S.
Prerequisite: 413.
Exotic space propulsion systems. Unsteady performance, dynamics, and control of turbo-engines. Blade element theory as applied to propellers and axial flow compressors, turbines and fans.

421. **PROBLEMS IN FLIGHT VEHICLE HEATING.**
(3-0) Cr. 3. W.
Prerequisite: 321, M.E. 321.
Sources of flight vehicle heating. Effect of heating on the structural analysis and design.

423. **ADVANCED STRUCTURAL ANALYSIS.**
(3-0) Cr. 3. S.
Prerequisite: 321.
Special methods of structural analysis, stability of structures typical of modern aerospace vehicles.

431. **FUNDAMENTALS OF FLIGHT CONTROL.**
(3-0) Cr. 3. F.
Prerequisite: 344, E.E. 441, Math. 322.
Fundamental knowledge pertaining to the analysis of automatic control systems for flight vehicles.

432. **FLIGHT CONTROL SYSTEMS.**
(3-0) Cr. 3. W.
Prerequisite: 431.
Control, guidance, and navigation systems as related to the performance of aerospace vehicles.

433. **FLIGHT SYSTEMS TESTING.**
(0-6) Cr. 3. S.
Prerequisite: 432.
Application of instrumentation to flight systems. Reduction and analysis of experimental data as obtained from aerospace systems. Aircraft, missile, and satellite testing.

441. **AERODYNAMIC THEORY I.**
(3-0) Cr. 3. F.
Prerequisite: 343, M.E. 321.
Introduction to classical theory of compressible and incompressible fluids. Shock and expansion waves.

442. **AERODYNAMIC THEORY II.**
(3-0) Cr. 3. W.
Prerequisite: 441.
Principles of compressible and incompressible flow. Application to airfoils, wings, and solids of revolution.

443. **VISCOUS AERODYNAMIC THEORY.**
(3-0) Cr. 3. S.
Prerequisite: 442.
Viscous flow theory. Boundary layer. Aerodynamic heating.

445, 446. **AEROSPACE VEHICLE PERFORMANCE.**
(3-0) Cr. 3 each. 445: W; 446: S.
Prerequisite: 445: 344; 446: 445.
Introduction to the aerodynamics, performance, stability, control, and critical maneuvering characteristics of aerospace vehicles such as V STOL aircraft, helicopters, hovercraft, and other short-range transportation vehicles.

452, 453. **FLIGHT MECHANICS II AND III.**
(3-0) Cr. 3 each. 452: W; 453: S.
Prerequisite: 352.
Orbital transfer methods. Lunar and interplanetary trajectories. Powered flight trajectories. Atmospheric entry problems.

455, 456. **INTRODUCTION TO HYDROSPACE ENGINEERING.**
(Geol. 455, 456) (3-0) Cr. 3 each. W.S.
Prerequisite: 455: Math. 213, Phys. 223; 456: 344, 455.
Introduction to elementary hydrospace vehicle performance, stability and control, and physical oceanography. Application of hydrospace principles to motion of vehicles under, on, or above the surface and instrumentation for hydrospace research.

461. **DESIGN AND ANALYSIS I.**
(3-0) Cr. 3. F.
Concepts of systems design as related to aerospace problems.

462. **DESIGN AND ANALYSIS II.**
(1-6) Cr. 3. W.
Prerequisite: 461.
Application of the principles and methods of analysis and design to the solution of aerospace problems.

463. **DESIGN AND ANALYSIS III.**
(1-6) Cr. 3. S.
Prerequisite: 462.
Application of the principles and methods of analysis and design to the solution of aerospace problems.

480. **FUNDAMENTALS OF AEROELASTICITY.**
(3-0) Cr. 3. S.
Prerequisite: 321, 344, E.M. 444.
Application of vibration theory and matrix analysis to elastic structures; eigen-value solutions of boundary value problems. Introduction to aeroelasticity and flutter.

490. **SPECIAL PROBLEMS.**
Arr. Cr. 1 to 6.
Prerequisite: 344.
A. Aero and or Gasdynamics.
B. Propulsion.
C. Stress Analysis.
D. Flight Mechanics.
E. Flight Systems.
F. Hydrospace.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

524. **THERMODYNAMICS OF COMPRESSIBLE FLOW II.**
(M.E. 524) See Mechanical Engineering.

531, 532. **AUTOMATIC CONTROLS FOR FLIGHT VEHICLES.**
(3-0) Cr. 3 each. 531: Alt. W; 532: Alt. S, offered 1972.
Prerequisite: 431 or equivalent.
Theory of the automatic control of flight vehicles. Spacecraft attitude control. Control of flexible vehicles. Optimal controls. Adaptive controls.

541, 542, 543. **ADVANCED AERODYNAMICS.**
(M.E. 541, 542, 543) (3-0) Cr. 3 each. Yr.
Prerequisite: 441.
Classical flow theory, compressible fluid theories, shock wave studies, and applications to aerodynamic shapes.

544. **ADVANCED AERODYNAMICS.**
(3-0) Cr. 3. F.
Prerequisite: 543.
Applications of classical flow theory, compressible fluid theories, and shock wave studies to aerodynamic shapes.

545. **FLIGHT PROPULSION SYSTEMS.**
(M.E. 545) See Mechanical Engineering.

549. **EXPERIMENTAL GAS DYNAMICS AND SHOCK TUBE THEORY.**
(M.E. 549) See Mechanical Engineering.

550, 551. **FLIGHT MECHANICS.**
(3-0) Cr. 3 each. F.W.
Prerequisite: 344, Math. 322.
Dynamical motion of flight vehicles. Powered flight trajectories and Keplerian motion. Rigid body motion of flight vehicles.

552. **PERFORMANCE ANALYSIS.**
(2-3) Cr. 3. S.
Prerequisite: 551.
Performance of aircraft, missiles, and space vehicles.

553. **ENTRY DYNAMICS.**
(3-0) Cr. 3. S.
Prerequisite: 551.
Atmospheric entry and entry dynamics of missiles and space vehicles.

561. **DESIGN AND ANALYSIS.**
(2-6) Cr. 4. S.
Prerequisite: 462 or equivalent; Math. 322.
Methods of analysis and theory of design. Applications to design problems of aircraft, missile, and space vehicles and their trajectories.

590. **SPECIAL TOPICS.**
Cr. 1 to 5.
A. Aero and/or Gasdynamics.
B. Propulsion.
C. Stress Analysis.
D. Flight Mechanics.
E. Flight Systems.
F. Magnetofluiddynamics.
G. Hydrospace.
H. Viscous Aerodynamics.

COURSES FOR GRADUATE STUDENTS, major or minor

610, 611. **AEROELASTICITY.**
(3-0) Cr. 3 each. 610: Alt. W; 611: Alt. S, offered 1972.
Prerequisite: 644, E.M. 444 or equivalent.
Interaction of aerodynamic, elastic, and inertial forces and the influence of this interaction on airplane design. Steady and unsteady aeroelastic problems.

615, 616. **OPTIMIZATION IN AEROSPACE ENGINEERING.**
(3-0) Cr. 3 each. 615: Alt. W; 616: Alt. S, offered 1973.
Prerequisite: 551, 543.
Applications of calculus of variations, method of gradients, dynamic programming, and other optimization techniques to problems in aerodynamics, flight mechanics, design, etc.

620. **SEMINAR.**
(1-0) Cr. 1.

623, 624. **MAGNETOFLUIDMECHANICS AND PLASMA DYNAMICS.**
(M.E. 623, 624) (3-0) Cr. 3 each. 623: Alt. F; 624: Alt. W, offered 1972-1973.
Prerequisite: 541, 542, 543, Math. 322.
623: Electromagnetic theory. Motion of charged particle in electromagnetic field. Equations of motion for viscous, heat, and electrically conducting fluids of multiple species. The Boltzmann equation. 624: Wave motions in magnetogasdynamics, electromagnetogasdynamics, and plasma dynamics. Engineering problems in magnetohydrodynamics and magnetogasdynamics. Ionization, radiation, electrical conductivity, and kinetic theory in plasma dynamics.

628. **RADIATION GAS DYNAMICS.**
(3-0) Cr. 3. Alt. S, offered 1973.
Prerequisite: 623.
Macroscopic treatment of the radiative energy transfer in gases. Conservation equations for radiation gas dynamics. Applications to one dimensional flow, normal shock waves and plane acoustic waves.

641, 642. **HYPERSONIC FLOW THEORY.**
(3-0) Cr. 3 each. 641: Alt. F; 642: Alt. W, offered 1971-1972.
Prerequisite: 543 or equivalent.
High Mach number flow theory. Theories of slender, blunt-nosed, and slightly blunt-nosed bodies in hypersonic flow. Minimum drag bodies. Hypersonic shock wave, small disturbance and Newtonian theories.

643. **HYPERSONIC VISCOUS FLOWS.**
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: 642.
Hypersonic boundary layer and viscous flow studies. Applications to slender and blunt bodies.

644. **APPLIED WING THEORY.**
(3-0) Cr. 3. Alt. F, offered 1971.
Prerequisite: 541, 544.
Methods of estimating the aerodynamic characteristics of swept and unswept, steady and oscillating wings in subsonic and supersonic flight.

647, 648, 649. **THE DYNAMICS OF REAL GASES.**
(3-0) Cr. 3 each. Alt. Yr, offered 1971.
Prerequisite: 543, Math. 322.
Application of real gas theory to flow behind a strong shock and in a rocket expansion nozzle. Involves harmonic and anharmonic oscillator theory, collisional transition probabilities, vibrational and chemical relaxation, together with their coupling effects at high temperatures.

650. **FLUID MECHANICS SEMINAR.**
(E.M. 650, M.E. 650) (1-0 to 3-0) Cr. 1 to 3 each time taken. F.
Prerequisite: Permission of instructor.
Special topics of current research interest to students and staff of departments concerned.

651, 652. **MECHANICS OF SPACE VEHICLE TRANSFERS.**
(3-0) Cr. 3 each. 651: Alt. W; 652: Alt. S, offered 1973.
Prerequisite: 551.
Vehicle transfer from one orbit to another orbit. Intercept and rendezvous techniques using rocket and or aerodynamic forces. Lunar and interplanetary space vehicle trajectories. Low-thrust space trajectories. Maneuvering of entry vehicles using rocket and or aerodynamic forces.

690. **SPECIAL TOPICS FOR ADVANCED GRADUATE STUDENTS.**
Cr. 1 to 5.
A. Aero and or Gasdynamics.
B. Propulsion.
C. Stress Analysis.
D. Flight Mechanics.
E. Flight Systems.
F. Magnetofluiddynamics.
G. Hydrospace.
H. Viscous Aerodynamics.

699. **RESEARCH.**

AGRICULTURAL EDUCATION

Harold R. Crawford, Ph.D., Head of Department

The Graduate Faculty

Members: C.E. Bundy; H.R. Crawford; J.B. McClelland

Associate Members: T.A. Hoerner; A.A. Kahler; R.L. Lawrence; V.J. Morford

The department offers work for the degrees Master of Science, Master of Education, and Doctor of Philosophy with a major in agricultural education and minor work to students taking major work in other departments.

Prerequisite to major graduate work in agricultural education is preparation substantially equivalent to the completion of the undergraduate curriculum in agricultural education offered at Iowa State University and adequate proof that the student ranks above average in scholastic ability and promise of vocational competency.

There is no foreign language requirement for the degrees Master of Science or Master of Education. A satisfactory reading knowledge of two languages—French, German, Russian, or Spanish—is required of doctoral candidates. At the discretion of the student's advisory committee, the foreign language requirement may be met by: (1) demonstrating a satisfactory reading knowledge of two foreign languages; (2) demonstrating a significantly higher degree of competence in one foreign language; (3) substituting two years of undergraduate study with a B average for one language; (4) substituting 9 credits of graduate work, in addition to the minimum Ph.D. requirements, in approved areas for one language or 18 credits for two languages. Students whose native language is not English may substitute competence in English for one of the languages.

Off-campus courses are offered for professional personnel in the field. Three-week courses are offered during the summer sessions for vocational agriculture and agricultural extension personnel.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

511. INSTRUCTIONAL AND ORGANIZATIONAL PROBLEMS OF BEGINNING TEACHERS OF VOCATIONAL AGRICULTURE.
(3-0) Cr. 3. Off-campus only. F.W.
Prerequisite: Fifteen credits in education.
Problems in instructional planning and methodology and in organizing the presecondary, secondary, postsecondary, FFA, and agricultural experience programs.

520. INSTRUCTIONAL TECHNIQUES AND MATERIALS IN AGRICULTURAL EDUCATION.
(3-0) Cr. 3. W. Off-campus. S.
Prerequisite: Fifteen credits in education.
Innovations and advanced principles in teaching methods and instructional plans and materials. Teaching decision making, programmed learning, demonstrations, field trips, team teaching, reference material selection, development and evaluation of instruction.

521. PROGRAMS FOR LEADERSHIP DEVELOPMENT IN AGRICULTURAL EDUCATION.
(3-0) Cr. 3. Alt. F, offered 1971.
Prerequisite: Fifteen credits in education.
Identification of leadership needs of participants in agricultural education programs. Principles of leadership development. Organization, implementation, and evaluation of individual and group leadership programs at presecondary, secondary and postsecondary levels.

538. POST HIGH SCHOOL EDUCATION IN AGRICULTURE.
(3-0) Cr. 3. Off-campus only. S.
Prerequisite: Fifteen credits in education.
Problems and needs of young and adult farmers and workers in off-farm agriculture, survey techniques, use of advisory councils, administrative relationship problems, program planning and evaluation. Departments are visited to observe programs and results.

539. OCCUPATIONAL EXPERIENCE PROGRAMS IN VOCATIONAL AGRICULTURE.
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: Fifteen credits in education.
Purposes of farm and off-farm occupational experience programs. Analysis of home farm and off-farm employment experience opportunities.

540. EDUCATIONAL IMPLICATIONS OF MANPOWER NEEDS IN AGRICULTURE.
(3-0) Cr. 3. Alt. F, offered 1972.
Prerequisite: Fifteen credits in education.
Analysis of manpower needs of farm and off-farm agriculture in individual communities, state, and nation. Methods in analyzing situations and in planning individual programs.

590. SPECIAL TOPICS IN AGRICULTURAL EDUCATION.
Cr. 1 to 5.
Prerequisite: Fifteen credits in education.

593. WORKSHOP IN AGRICULTURAL EDUCATION.
Cr. 1 to 5. F.W.S.SS.
Prerequisite: Fifteen credits in education.
A. High school vocational agriculture teachers.
B. Beginning vocational agriculture teachers.
C. Post-secondary agricultural teachers.
D. Cooperating teachers.

COURSES FOR GRADUATE STUDENTS, major or minor

604. EVALUATION AND PROGRAM PLANNING IN AGRICULTURAL EDUCATION.
(3-0) Cr. 3. SSI. Alt. S, offered 1973.
Prerequisite: Fifteen credits in education.
Criteria and procedures for evaluation of programs in agricultural education. Adoption and implementation of evaluation results in program organization, administration, and content.

615. SEMINAR IN AGRICULTURAL EDUCATION.
(1-0 to 3-0) Cr. 1 to 3. F.W.S.SS.

630. PHILOSOPHY AND POLICY MAKING IN AGRICULTURAL EDUCATION.
(3-0) Cr. 3. Alt. W, offered 1973.
Prerequisite: Fifteen credits in education.
Basic philosophic premises in development of agricultural education programs at federal, state, and local levels. Impact of legislation on state and local policy making. Role of state and local advisory groups in policy making.

699. RESEARCH.

AGRICULTURAL ENGINEERING

Clarence W. Bockhop, Ph.D., Head of Department

The Graduate Faculty

Members: C.E. Beer, C.W. Bockhop, W.F. Buchele, L.F. Charity, H. Giese, T.E. Hazen, H.P. Johnson

Associate Members: T.A. Hoerner, G.L. Kline, S.J. Marley, J.R. Miner, D.B. Palmer, T.L. Willrich

The department offers work for the degrees Master of Science, Master of Engineering, and Doctor of Philosophy with major in agricultural engineering. Within the major the student may specialize in soil and water resources, field power and machines, materials handling, crop conditioning and processing, agricultural structures and environment, and animal waste management.

Prerequisite to major graduate work is the completion of an undergraduate curriculum substantially equivalent to that required of agricultural engineering undergraduate students at this institution.

Minor work in agricultural engineering is offered for students in other departments, and minor work in agricultural mechanics is offered for students in agriculture.

A foreign language is not required for the degree of Master of Science or Master of Engineering. The language requirement for the degree Doctor of Philosophy may be satisfied by one of three ways: (1) Demonstrate a satisfactory reading knowledge of two foreign languages approved by the department. (2) Demonstrate a significantly higher degree of communication competence for one foreign language. (3) Demonstrate a satisfactory reading knowledge of one foreign language and scholarly achievement in a minimum of 9 credits of course work in the social sciences and humanities.

COURSES FOR GRADUATE STUDENTS, minor only*

306. SOIL AND WATER MANAGEMENT.
(2-3) Cr. 3. F.S.SSI.
Engineering aspects of soil and water conservation for students in agriculture. Use of the level. Land description. Design, location, and construction of erosion control and drainage facilities. Field trips to problem areas.

345. TRACTOR POWER.
(2-3) Cr. 3. W.
Prerequisite: 334.
Construction, operation, adjustment, capacity, and care of tractors and internal combustion engines.

346. AGRICULTURAL TRACTOR POWER.
(3-3) Cr. 4. S.SSI.
Prerequisite: M.E. 321.
Kinematics and dynamics of tractor power application; draw bar, power take-off, and traction mechanisms. Thermodynamic principles and construction of the internal combustion engine, fuels and carburetion, ignition. Rating and testing of tractors.

354. ADVANCED METAL CONSTRUCTION AND MAINTENANCE.
(2-4) Cr. 3. F.W.S.SSI.
Prerequisite: 254.
Advanced techniques in metal construction and repair of agricultural equipment including oxy-acetylene and arc welding.

364. FARM ELECTRICITY.
(2-3) Cr. 3. F.W.S.SSII.
Use of electricity in productive farm enterprises and in the improvement of farm livings. Electrical safety and protection. Motors, controls, and wiring for work simplification.

366. CROP CONDITIONING AND HANDLING SYSTEMS
(2-3) Cr. 3. F.
Principles, methods, and management practices in drying agricultural crops with emphasis on corn. Principles and selection of materials-handling systems, including augers, bucket elevators, and belt conveyors.

371. WATER USE IN OUTDOOR RECREATION.
(3-0) Cr. 3. W.
Recognition and definition of problem areas in outdoor recreation. Water sources, quantity and quality considerations, wastes disposal, irrigation and drainage, mapping.

377. AGRICULTURAL STRUCTURES AND ENVIRONMENT.
(3-3) Cr. 4. W.
Prerequisite: 231, E.M. 324, classification in M.E. 321.
Structural and environmental problems in agricultural buildings. Analysis of materials used in agricultural buildings. Design of light-framed structures. Environmental control in livestock buildings, product storage, and plant production.

411. AGRICULTURAL MACHINERY MAINTENANCE AND ADJUSTMENT.
(8-8) Cr. 4. Alt. SSI, offered 1971. Three weeks.
Prerequisite: Permission of instructor.
Operating principles, adjustment, and maintenance of tillage, planting, fertilizing, spraying, and harvesting equipment.

412. ELECTRICITY IN FARMSTEAD MECHANIZATION.
(8-8) Cr. 4. Alt. SSI, offered 1972. Three weeks.
Prerequisite: Permission of instructor.
Planning the farmstead electrical systems for economy, work simplification, and safety. Characteristics and application of motors and controls to livestock and poultry production. Development of demonstrations and instructional materials for the teaching of mechanization of the farmstead.

415. TEACHING AGRICULTURAL MECHANICS I.
(2-2) Cr. 3. F.W.S.
Prerequisite: 254, 255.
Objectives and methods; equipment and management of the shop; organization of shop program. Students will plan and present demonstrations of methods of teaching mechanical skills.

417. TEACHING AGRICULTURAL MECHANICS II.
(3-0) Cr. 3. S. Off-campus.
Prerequisite: 415.
Organization of instructional units; selection of tools, equipment, supplies, and reference materials; development and organization of facilities for instruction in high school and vocational-technical programs.

418. DEVELOPMENTS IN AGRICULTURAL MECHANICS.
(1-2 or 2-4) Cr. 1 or 2. F.W.SS. Off-campus. Five weeks.
Selection, principles of operation, application and maintenance of equipment and materials used in mechanized agriculture and development of instructional units for vocational-technical programs.

A. Small Gasoline Engines.
B. Electric Motors.
C. Controls for Automation in Agriculture.
D. Electricity in Agriculture.
E. Materials for Agricultural Structures.
F. Tractor Engines.
G. Hydraulics in Agriculture.
H. Metal Construction.
I. Agricultural Machinery.

419. ENVIRONMENTAL SYSTEMS FOR ANIMAL PRODUCTION.
(3-0) Cr. 3. F.S.SSI.
Effects of thermal environment on animal performance. Ventilation and insulation for animal housing. Functional planning of animal facilities. Feed-processing systems. Economic considerations of buildings and equipment. Not open to students having credit in A.E. 219.

424. HYDRAULIC DESIGN OF SOIL AND WATER CONTROL FACILITIES.
(3-3) Cr. 4. W.
Prerequisite: E.M. 378.
Application of open-channel flow principles to the design of irrigation, drainage, and erosion control facilities. Hydraulics of conduits, and stilling basins. Hydraulics of pumps. Spatially varied flow. Flow through porous media.

425. IRRIGATION AND DRAINAGE ENGINEERING.
(2-3) Cr. 3. S.
Prerequisite: 232, 424.
Theory of subsurface drainage. Irrigation of field crops. Design of surface and sprinkler irrigation systems. Use of computers in solving soil and water conservation problems.

435. AGRICULTURAL MACHINERY DESIGN I.
(0-3) Cr. 1. F.
Prerequisite: Credit or classification in M.E. 420.
Creative approach to identification and analysis of agricultural machinery needs, critical evaluation of proposed solutions.

436. AGRICULTURAL MACHINERY DESIGN II.
(2-6) Cr. 4. W.
Prerequisite: 232, 435, credit or classification in M.E. 421.
Design, development, and testing of farm machinery to meet the functional requirements of machines for tillage, seeding, cultivation and weed control, harvesting, crop processing, and farm power units.

437. POWER AND CONTROL HYDRAULICS.
(2-2) Cr. 3. S.
Prerequisite: E.M. 378.
Significance of hydraulic fluid properties. Performance parameters for fixed and variable displacement pumps and motors. Analysis of pressure, flow, and directional control valves. Analysis and design of hydraulic systems for power and control functions.

461. ELECTRICAL ENERGY APPLICATIONS IN AGRICULTURE.
(2-6) Cr. 4. F.
Prerequisite: Credit or classification in E.E. 445.
Characteristics of motors and controls and applications to agricultural machines. Instrumentation and techniques applied to agricultural production.

464. CROP CONDITIONING AND STORAGE.
(2-3) Cr. 3. W.
Prerequisite: Math. 321, M.E. 321.
Mass and energy balances involved in the conditioning and storage of agricultural crops. Fans, motors, and circuits. Air distribution in ducts. In-storage, heated-air, and supplemental-heat drying.

465. PROPERTIES AND PROCESSING OF AGRICULTURAL MATERIALS.
(2-3) Cr. 3. S.
Prerequisite: 231.
Theory and practice involved in the handling of agricultural products. Rheological, thermal, and mechanical properties of products. Component and system design.

471. PRINCIPLES OF LIVESTOCK WASTE MANAGEMENT.
(3-3) Cr. 4. S.
Prerequisite: Chem. 231.
Principles of chemistry, bacteriology, and engineering applied to the collection, treatment, and disposal of animal wastes.

477. ADVANCED AGRICULTURAL STRUCTURES AND ENVIRONMENT.
(2-4) Cr. 4. W.
Prerequisite: 377, M.E. 426, C.E. 434.
Analysis and design of light framed structures and environmental control systems for animal production, plant production, crop storage and processing of agricultural products.

490. SPECIAL PROBLEMS.
Cr. 1 to 5.
P. Power and Machinery.
Q. Structures and Environment.
R. Electric Power and Processing.
S. Soil and Water.
T. Construction and Maintenance.

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*Open to graduate students for minor credit only in agricultural engineering: 346, 377, 424, 425, 435, 436, 437, 461, 464, 465, 471, 477, 490. Open to non-engineering graduate students for minor credit only in agricultural mechanics: 306, 345, 354, 364, 366, 371, 411, 412, 415, 417, 418, 419, 490.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

524. EROSION AND SEDIMENT TRANSPORT.
(3-0) Cr. 3. Alt. F, offered 1971.
Prerequisite: Math. 213 and one of the following: 424, C.E. 571, Geol. 431, Agron. 577.
Initiation of sediment motion and overland flow. Flow in alluvial channels and theory of transport. Soil surface and channel stability; regime of channels. Application of dimensional analysis to erosion and scour problems.

526. FREQUENCY DISTRIBUTIONS IN HYDROLOGIC DATA ANALYSIS.
(3-0) Cr. 3. Alt. W, offered 1972.
Prerequisite: Stat. 401 or 447.
Theory and use of log normal, Weibull, and extreme value distributions. Application of computer programs to fit selected hydrologic data.

531. DESIGN CRITERIA FOR AGRICULTURAL STRUCTURES.
(3-0) Cr. 3. F.
Prerequisite: 377.
Development of physical and environmental design criteria essential to buildings and related equipment used in the production of livestock and storage of crops. Research needs and techniques.

532. ADVANCED SOIL AND WATER CONTROL ENGINEERING.
(3-0) Cr. 3. W.
Prerequisite: 424.
Land and water resource development for agriculture. Relationship of the engineer to resource development. Research and development in soil and water conservation engineering.

533. AGRICULTURAL POWER AND MACHINERY.
(3-0) Cr. 3. S.
Prerequisite: 346.
Critical analysis of power and equipment for agricultural production with emphasis on functional design requirements, and techniques for testing and evaluating performance.

534. ADVANCED FARM ELECTRIFICATION.
(3-0) Cr. 3. S.
Prerequisite: 461.
Critical analysis of electric power, heat, light, and controls in agricultural production with emphasis on functional design requirements; instrumentation methods and results.

590. SPECIAL TOPICS.
Cr. 1 to 5.
N. Crop Conditioning and Storage.
P. Power and Machinery.
Q. Structures and Environment.
R. Electric Power and Processing.
S. Soil and Water.
T. Construction and Maintenance.

COURSES FOR GRADUATE STUDENTS, major or minor

637. SOIL DYNAMICS.
(2-3) Cr. 3. Alt. W, offered 1972.
Prerequisite: E.M. 324, 345; Agron. 577 or C.E. 360.
Analysis of the stress-strain relationship of soil under dynamic loads. Slip-sinkage relationship of tractive devices. The relationship between tillage energy and compactive energy.

638. HARVESTING MACHINES.
(2-3) Cr. 3. Alt. W, offered 1973.
Prerequisite: 436, 533.
Principles of cutting, gathering, threshing and separating of grains. Effects of maturity, crop condition, and environment on grain damage and harvesting efficiency. Analysis of harvesting devices.

661, 662, 663. SEMINAR.
(1-0) Cr. 1 each. Yr.
Discussion of research problems, methods, procedures, and reports.

671. ADVANCED TOPICS IN WATER RESOURCES ENGINEERING.
(C.E. 671) See Civil Engineering.

699. RESEARCH.
N. Crop Conditioning and Storage.
P. Power and Machinery.
Q. Structures and Environment.
R. Electric Power and Processing.
S. Soil and Water.

AGRONOMY

John T. Pesek, Jr., Ph.D., Head of Department

The Graduate Faculty

Members: M. Amemiya, I.C. Anderson, R.E. Atkins, C.A. Black, J.M. Bremner, G.M. Browning, I.T. Carlson, L.C. Dumenil, S.A. Eberhart, L.L. Frederick, K.J. Frey, A.R. Hallauer, J.J. Hanway, C.F. Hodges, J.L. Jarvis, D. Kirkham, W.C. Moldenhauer, R.B. Pearce, L.H. Penny, J. Pesek, P.A. Peterson, W.H. Pierre, F.F. Riecken, W.A. Russell, W.H. Scholtes, A.D. Scott, R.H. Shaw, R.M. Shibles, W.D. Shrader, L.M. Thompson, J.R. Webb, W.F. Wedin, D.G. Wolley, D.N. Yarger.

Associate Members: W.G. Biggs, C.J. deMooy, W.R. Fehr, T.E. Fenton, J.R. George, D.E. Green, F.F. Troeh, R.D. Voss.

The department offers work for the degrees Master of Science and Doctor of Philosophy with major in crop production and physiology, plant breeding, soil physics, soil chemistry, soil fertility, soil microbiology and biochemistry, soil morphology and genesis, soil management and agricultural climatology. Minor work is provided for students taking major work in other departments. A nonthesis option is available for the master's degree.

Prerequisite to major graduate work in crop science and soil science is completion of an undergraduate curriculum substantially equivalent to that recommended for pregraduate training in the agronomy curriculum at this institution. The foreign-language requirement, if any, for the M.S. and Ph.D. degrees is established on an individual basis by the advisory committee appointed to guide the work of the student.

COURSES FOR GRADUATE STUDENTS, minor only

315. CROP GROWTH AND CULTURE.
(4-0) Cr. 4. F.W.S.Alt. SSI, offered 1972.
Prerequisite: 114, Biol. 101, Chem. 231 recommended.
Physiological aspects of crop growth; application to cultural practices.

354. SOIL FERTILITY.
(3-3) Cr. 4. F.W.S.SSII.
Prerequisite: 154, 12 credits of chemistry. Frederick.
Chemical, biological, and physical properties of soils in relation to plant growth and development. Nutrient behavior in the soil. Fertility evaluation. Principles guiding use of lime, manure, and fertilizers.

364. SOIL RESOURCE CONSERVATION.
(2-3) Cr. 3. F.S.
Prerequisite: 154 or 357.
Relation of soil properties and land morphology to erosion. Principles and methods of conserving soil. Preparation of a land-use plan. Out-of-town field trips.

406. CLIMATES OF THE CONTINENTS.
(Mteor. 406) (3-0) Cr. 3. W.
World climatology and factors controlling it. Climatic analogues as a means of comparing climates. The climates of different continents.

415. WORLD CROPS: ADAPTATION AND DISTRIBUTION.
(3-0) Cr. 3. F. Alt. SSI, offered 1973.
Prerequisite: 114, Biol. 101.
Origin and adaptation of crop plants. Influence of environmental factors on distribution and production of cereal, oil, fiber, sugar, and other crops.

417. PRINCIPLES OF CROP PRODUCTION AND MANAGEMENT.
(3-0) Cr. 3. A: Alt. SSI, offered 1972. Three weeks. B: S, offered on request.
Prerequisite: Graduate classification. For those students not majoring in agronomy.
Application of principles of crop science and current research information in the solution of crop production problems.

424. PRINCIPLES OF PLANT BREEDING I.
(3-0) Cr. 3. F.S.
Prerequisite: 415 or 315; Gen. 301.
Basic principles used in improvement of field crops. Pure line, mass selection, and multi-line concepts; hybridization, pedigree and bulk systems, backcrossing, inbreeding, and other breeding procedures in relation to self- and cross-fertilizing species.

444. SOIL AND CROP MANAGEMENT.
A: Soil Management (2-0) Cr. 2. F.W.S.SSI.
Prerequisite: 354. Stritzel.
B: Crop Management (2-0) Cr. 2.
(4-0) Cr. 4. F.W.S.SSI.
Prerequisite: 212 or 315. Woolley.
Integrating the principles of agronomic science with soil and crop management systems and practices. Basic plant-soil-climate relationships are used in solving field problems with emphasis on achieving optimum land use and efficient crop production.
While the courses can be taken as single, independent units, it is recommended that they be taken jointly.

453. FERTILIZERS.
(3-0) Cr. 3. F.W.
Prerequisite: 354. Stritzel.
Types, properties, and production of fertilizers; choice and use of fertilizer in relation to soil properties, environmental conditions, crop requirements, and economic factors.

457. SOIL CHEMISTRY AND PHYSICS.
(3-3 or 3-0) Cr. 3 or 4. W.
Prerequisitie: 354.
Chemical, physical, and mineralogical properties of soils. Influence of particle size on soil properties. A study of the colloidal system and the movement of materials in soils.

473. **SOIL GENESIS AND SURVEY.**
(2-5) Cr. 5. F.S.
Prerequisite: 154 or 357.
Development, characteristics, and identification of soils; study of soil profiles and surfaces; remote sensing; theory and practice of soil mapping; interpretation and utilization of soil survey information; two 2-day field trips.

483. **WORLD SOIL RESOURCES.**
(2-0) Cr. 2. Alt. W, offered 1973.
Prerequisite: Chem. 141 or 147.
Properties of soils; world soil geography; present and potential productivity of soils in various continents, and factors influencing their utilization.

485. **AGRO-MICROBIOLOGY.**
(Bact. 485) (3-3 or 5) Cr. 4 or 5. F.S.
Prerequisite: 154, Bact. 300. Frederick.
Role of microorganisms in soil-plant environment. Carbon, nitrogen, and mineral transformations. Ecological relationships. Applications to fertility, inoculation, pesticides, pollution control, and feed storage.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

500. **ORIENTATION SEMINAR.**
(1-0) Cr. 1. F.
Prerequisite: Graduate classification in agronomy, and from foreign country. Pesek and staff.
An introduction to Iowa and U.S. agriculture for international scholars. Field trips when possible. Departmental role in the functioning of research, teaching, and extension in fulfilling the charge given the land-grant university.

505. **MICROCLIMATOLOGY.**
(Mteor. 505) (3-0) Cr. 3. S.
Prerequisite: 206, or graduate classification. Shaw.
The heat exchange near the ground. Relation of topography and plant cover to the microclimate. Modification of micro-climate by agricultural operations.

506. **METHODS IN CLIMATOLOGY.**
(Mteor. 506) (3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: 505, Stat. 448. Shaw.
Physical and statistical processes in the study of the climate and the analysis of agro-climatic data.

514. **ADAPTATION AND ECOLOGY OF WORLD CROPS.**
(3-0) Cr. 3. F.
Prerequisite: 114, Bot. 310, Gen. 301.
Principles and concepts of origin, evolution, adaptation and ecology of world crops. Genetic and physiologic aspects of plant response to environment. Distribution of world crops on a climate basis.

518. **ADVANCED CROP PRODUCTION.**
(3-0) Cr. 3. W.
Prerequisite: 315 or 444. Woolley.
Basic concepts in plant-soil-climate relationships with emphasis on recent advances in crop culture and management.

524. **PRINCIPLES OF PLANT BREEDING II.**
(3-0) Cr. 3. W.
Prerequisite: 424, Bot. 407. Atkins.
Application of genetic principles to improvement of field crops. Topics covered include interspecific and intergeneric hybridization, induced polyploidy, induced mutations, sterility mechanisms, character inheritance and specific breeding considerations related to a spectrum of crop species.

534. **PASTURE AND FORAGE RESEARCH METHODS.**
(3-0) Cr. 3. Alt. W, offered 1973.
Prerequisite: Stat. 401 and Agron. 434, or permission of instructor. Wedin.
Research methods for pasture and forage intake-quality assessment in studies either dependent or independent of animal effects. Adaptation of methods to developing grassland situations. Analyses and interpretations of pasture and forage research results, with considerations of forage economics.

553. **SOIL-PLANT RELATIONSHIPS.**
(3-0) Cr. 3. F.
Prerequisite: 354. Black.
Composition and properties of soils in relation to the nutrition and growth of plants.

556. **LABORATORY METHODS OF SOILS INVESTIGATIONS.**
(0-4 to 6) Cr. 2 to 3. A: Alt. S, offered 1972; B: F.; C: W.
Prerequisite: A: 485. Bremner, Frederick; B: 354, Chem. 211. Black; C: 577. Kirkham.
A: Soil Microbiology and Biochemistry.
B: Soil Chemistry.
C: Soil Physics.

561. **IRRIGATION AGRICULTURE.**
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: 354. Troeh.
Properties of soils in relation to irrigation; use and quality of irrigation water; reclamation of saline and sodic soils; soil-plant-water relationships; management of irrigated cropland; irrigation in humid regions.

565. **ADVANCED SOIL MANAGEMENT AND CONSERVATION.**
(3-0) Cr. 3. Alt. W, offered 1972.
Prerequisite: 364, 473, A.E. 306. Shrader.
Fundamental principles involved in the management, improvement, and conservation of soils.

575. **SOIL MORPHOLOGY, GENESIS, AND CLASSIFICATION.**
(3-0) Cr. 3. W.
Prerequisite: 473, 553. Fenton.
Morphology and formation of soils, systems of classification, and geographical distribution of soils.

577. **SOIL PHYSICS.**
(3-0) Cr. 3. F.
Prerequisite: 354, Math. 112 recommended. Kirkham.
Relation of physical properties of soils to plant growth. Particle-size distribution, soil structure, clay minerals, soil moisture, rheological properties, and soil temperature.

585. **SOIL MICROBIOLOGY AND BIOCHEMISTRY.**
(Bact. 585) (3-0) Cr. 3. W.
Prerequisite: 485. Frederick.
Nature of the microbiological population of the soil; activities of soil microorganisms, interactions between soil population and soil properties and plant growth; interpretation of biological data.

590. **SPECIAL TOPICS.**
Cr. arr.
Prerequisite: Fifteen credits in agronomy.
Literature reviews and conferences on selected topics in crops, soils, or climatology according to needs and interest of student. For foreign students, an analysis of soil, climatic, and crop production resources of the student's home country is suggested.

COURSES FOR GRADUATE STUDENTS, major or minor

600. SEMINAR.
(1-0) Cr. 1. F.W.S.
Reports and discussions of recent literature and current investigations.
A. Crops. Carlson, Fehr, Hallauer.
B. Soils. Black.
C. Soil-Plant-Climate. Shaw.

609. AGRICULTURAL CLIMATOLOGY.
(0-1) Cr. 1. F.W.S.SS. Shaw.
Consultation with instructor, special problems, and/or reports on reading assigned in consultations with the instructor.

615. ENVIRONMENTAL CROP PHYSIOLOGY.
(3-0) Cr. 3. S.
Prerequisite: Fundamental background in plant physiology and crop science. Shibles.
The plant-environment interaction in relation to growth and production of crop communities.

620. COLLOQUIUM IN CROP PHYSIOLOGY.
(0-2) Cr. 1. W.
Prerequisite: Graduate classification and permission of instructor. Anderson, George, Pearce, Shibles, Wedin, Woolley.
Presentation of papers and informal discussion of selected literature topics in crop physiology.

623. CYTOGENETICS IN PLANT BREEDING.
(3-0) Cr. 3. F.
Prerequisite: 524, Gen. 401, Bot. 605. Peterson.
Cytogenetics in plant breeding. Topics include chromosome recombination, principles of chromosome pairing, distribution of genetic materials, aberrations, polyploids, genome relations, aneuploids, nullisomic analysis, and interspecific hybrids.

624. ADVANCED PLANT BREEDING I.
(3-0) Cr. 3. W.
Prerequisite: 524, Gen. 630. Russell.
Types of gene action in plant breeding. Topics include heritability, inbreeding depression and heterosis, development and evaluation of parental materials, prediction of hybrid performance, procedures and problems in testing for general and specific combining ability, factors limiting efficiency of selection and testing.

625. ADVANCED PLANT BREEDING II.
(3-0) Cr. 3. S.
Prerequisite: 524, 624, Gen. 630. Frey.
Relation of population structure to plant breeding. Topics include breeding systems; relation of population structure to inducing variability and to selection procedures; theory of pure lines, synthetics, and multi-line varieties; importance of genetic shifts and homeostasis in plant breeding.

655. ADVANCED SOIL FERTILITY.
(3-0) Cr. 3. Alt. W, offered 1973.
Prerequisite: 553. Black.
Evaluation of soil fertility and fertilizers; theory and applications.

657. SOIL CHEMISTRY.
(2-0) Cr. 2. Alt. S, offered 1973.
Prerequisite: 553, Chem. 494 or equivalent. Scott.
Chemical and mineralogical properties of soil colloids. Ion exchange and soil reaction.

675. ADVANCED SOIL GENESIS AND CLASSIFICATION.
(0-2) Cr. 2. Alt. S, offered 1972.
Prerequisite: 575. Riecken.
Processes, reactions, and theories in soil formation; principles of soil classification.

677. ADVANCED SOIL PHYSICS.
(3-0) Cr. 3. Alt. S, offered 1973.
Prerequisite: 577, Math. 112, Math. 313 recommended. Kirkham.
The flow and distribution of water, gas, and heat in soils. Physical principles and applications.

685. ADVANCED SOIL BIOCHEMISTRY.
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: 585. Bremner.
Nature of soil organic matter, and biochemical transformations brought about by soil microorganisms.

699. RESEARCH.
A. Agricultural Climatology.
B. Crop Production and Physiology.
C. Plant Breeding and Cytogenetics.
D. Soil Chemistry.
E. Soil Fertility.
F. Soil Management.
G. Soil Microbiology and Biochemistry (Bact. 699)
H. Soil Morphology and Genesis.
I. Soil Physics.

ANIMAL SCIENCE

L.N. Hazel, Ph.D., Head of Department

The Graduate Faculty

Members: L.L. Anderson, S.L. Balloun, W. Burroughs, R.C. Ewan, C.F. Foreman, A.E. Freeman, D.E. Goll, L.N. Hazel, N.L. Jacobson, E.A. Kline, J.L. Lush, A.D. McGilliard, W.W. Marion, R.M. Melampy, A.W. Nordskog, H.L. Self, V.C. Speer, M.H. Stromer, A.H. Trenkle, R.L. Vetter, R.L. Willham, J.W. Young.

Associate Members: D.C. Beitz, P.O. Brackelsberg, L.L. Christian, S.A. Ewing, H.H. Hodson, M.H. Jurgens, F.C. Parrish, A.R. Porter, J.A. Sims, D.G. Topel, D.R. Zimmerman.

The department offers work for the degrees Master of Science and Doctor of Philosophy in animal breeding, animal nutrition, meat science, muscle biology, nutritional physiology, physiol-

ogy of reproduction, poultry breeding, poultry nutrition, and poultry products technology. Minor work is offered in these areas to students taking major work in other departments. For students desiring more general training than in the above specialized areas, the degree Master of Science is offered in animal production. In this program additional course work may be substituted for a thesis.

A strong undergraduate program is required for those students interested in graduate study. Fundamental training in biology, chemistry, mathematics, and statistics is prerequisite to a satisfactory graduate program. Graduate programs in animal science include supporting work in areas such as agronomy, anatomy, bacteriology, biochemistry, chemistry, economics, food technology, genetics, physiology, and statistics. Not infrequently, students choose graduate programs involving a joint major with one of these areas.

There is no foreign language requirement for the degree Master of Science. The foreign language requirement for the degree Doctor of Philosophy may be met by (a) obtaining a score of 460 or greater on the Educational Testing Service foreign language examination, or (b) passing one academic year of one foreign language (taken either as an undergraduate or graduate student) with a grade of C or better. In exceptional cases, the advisory committee may recommend that the requirements be changed to meet the needs of the individual candidate.

COURSES FOR GRADUATE STUDENTS, minor only

318. FUNDAMENTALS OF NUTRITION.
(4-0) Cr. 4. F.W.S.SSI.
Prerequisite: Organic chemistry; physiology recommended. Haynes, Young.
Digestion and metabolism of carbohydrates, fats, proteins, minerals, and vitamins. Measures of energy.

319. APPLIED ANIMAL NUTRITION.
(3-0) Cr. 3. F.W.S.SSII.
Prerequisite: 318. Foreman, Jurgens, Zimmerman.
Essential nutritive requirements of livestock and poultry, sources and composition of nutrients, replacement value of feeds in rations, identification of ingredients, ration formulation, and feeding recommendations.
A student may not count credit for both 218 and 319 toward a degree.

350. PRINCIPLES OF ANIMAL BREEDING.
(3-0) Cr. 3. F.W.S.SSI.
Prerequisite: Gen. 301 or 350; Stat. 101. Wunder.
The genetic and environmental bases of animal differences. Performance testing, selection, and mating systems.

351. APPLIED ANIMAL BREEDING.
(2-2) Cr. 3. F.W.S.SSII.
Prerequisite: 350. Sims.
Application of quantitative genetic principles in evaluating seedstock. Methods of measuring and analyzing economic traits. Simulated breeding herd and flock selection.

420. POULTRY NUTRITION.
(3-2) Cr. 4. F.
Prerequisite: 318. Balloun.
Theoretical and practical aspects of poultry nutrition. Ration formulation, mixing, and feeding tests. Feeding programs and requirements at different ages.

423. POULTRY PRODUCTION.
(3-0) Cr. 3. W.S.
Practical feeding and management of chicken and turkey flocks. Operational study of commercial farms, including production and marketing practices.

425. PORK PRODUCTION.
(3-0) Cr. 3. F.W.S.Alt. SSI, offered 1972.
Prerequisite: 319, 350; 351 recommended. Christian.
Life-cycle swine production.

427. BEEF PRODUCTION.
(4-0) Cr. 4. F.W.S.Alt. SSI, offered 1973.
Prerequisite: 319, 350; 351 recommended. Brackelsberg.
The beef industry from conception to consumption. Cow-calf and feedlot operations.

429. SHEEP PRODUCTION.
(3-0) Cr. 3. W.SSI.
Prerequisite: 319, 350; 351 recommended. Warner.
Calendarized farm flock program. Programs for feeder lambs. Wool.

431. ANIMAL REPRODUCTION I.
(4-0) Cr. 4. F.W.S.
Prerequisite: V.Phys. 264 or equivalent. Melampy.
Comparative anatomy, physiology, and endocrinology of animal reproduction.

434. MILK PRODUCTION.
(3-0) Cr. 3. F.W.S.
Prerequisite: 319, 350. Foreman.
Economics of milk production. Facilities, feeding, management of the milking herd. Raising replacements.

436. DAIRY PROBLEMS.
(3-0) Cr. 3. W.
Prerequisite: 350, 434. Porter.
Seminar and discussion of current problems for the dairyman.

437. MILK SECRETION.
(3-0) Cr. 3. F.
Prerequisite: 318 or permission of instructor. Jacobson.
Development, structure, and functional processes of the mammary gland. Nutritional relationships.

470. MEAT SCIENCE.
(3-3) Cr. 4. F.S.
Prerequisite: 170. Parrish.
Structure and composition of skeletal muscle and connective tissue. Microbiology of meat. Post-mortem changes affecting meat and meat quality. Fundamentals involved in meat processing preservation. One-day field trip.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

503. **SEMINAR IN ANIMAL PRODUCTION.**
(1-0) Cr. 1. F.S.
Discussion and evaluation of current topics in animal production and management.

506. **ANIMAL EXPERIMENTATION.**
(3-2) Cr. 4. W.
Prerequisite: Stat. 401. Christian.
The scientific method in animal research. Recognizing and defining important problems in the livestock industry. Emphasis upon planning and conducting animal experiments and interpretation of the observed results.

518. **ADVANCED NONRUMINANT NUTRITION.**
(2-0) Cr. 2. W.
Prerequisite: 319. Speer.
Nutrition requirements for maintenance, growth, fattening, reproduction, and lactation in the nonruminant animal.

519. **ADVANCED RUMINANT NUTRITION I.**
(3-0) Cr. 3. S.
Prerequisite: 319. Burroughs.
Digestion, absorption, and metabolism of nutrients as related to maintenance growth, lactation, and reproduction in ruminants.

520. **ADVANCED RUMINANT NUTRITION II.**
(2-3) Cr. 3. Alt. F, offered 1972.
Prerequisite: Permission of instructor. McGilliard.
Survey of outstanding literature on methodology as applied to the study of the physiological aspects of ruminant nutrition. Laboratory to illustrate principles, methods, and special procedures.

531. **ANIMAL REPRODUCTION II.**
(3-0) Cr. 3. F.S.
Prerequisite: 431. Anderson.
Endocrine aspects of animal reproduction.

550. **GENETIC IMPROVEMENT OF FARM ANIMALS.**
(3-0) Cr. 3. S.
Prerequisite: 351, Stat. 401. Willham.
Gene frequency, gene effects, genetic variation, and covariation in productive traits. Adjusting for environmental differences and estimated breeding value. Mass, pedigree, family selection, and progeny testing. Selection indexes. Breeding plans for maximizing rates of improvement.

590. **SPECIAL TOPICS.**
Cr. 1 to 3.
Special topics in the animal sciences, offered on demand and often conducted by guest professors.
A. Animal Breeding.
B. Animal Nutrition.
C. Meat Animal Production.
D. Dairy Production.
E. Meat Science.
F. Reproductive Physiology.
H. Poultry Nutrition.
I. Poultry Products.

COURSES FOR GRADUATE STUDENTS, major or minor

603. **SEMINAR IN ANIMAL NUTRITION.**
(1-0) Cr. 1. F.W.S.
Prerequisite: Permission of instructor.
Discussion of current literature; preparation and submission of abstracts.

605. **METHODS AND TECHNIQUES IN ANIMAL NUTRITION EXPERIMENTATION.**
(2-3) Cr. 3. F.
Prerequisite: Stat. 401. Zimmerman.
Methods and techniques in planning and conducting nutrition experiments with poultry, swine, cattle, and sheep. Includes visits to experimental facilities.

614. **ADVANCED POULTRY NUTRITION.**
(2-2) Cr. 3. Alt. S, offered 1972.
Prerequisite: Permission of instructor. Balloun.
Requirements, interaction, and metabolism of nutrients by chickens and turkeys. Development and testing experimental diets, including deficiency studies.

618. **ADVANCED NUTRITION—MINERALS AND VITAMINS.**
(4-0) Cr. 4. F.
Prerequisite: B.&B. 406 or equivalent. Ewan.
The role of vitamins and minerals in mammalian intermediary metabolism. Integration of cellular biochemistry and physiology of vitamins and minerals.

619. **ADVANCED NUTRITION—PROTEIN.**
(3-0) Cr. 3. W.
Prerequisite: B.&B. 406 or equivalent. Trenkle.
Digestion, absorption, and intermediary metabolism of amino acids and protein. Integration of cellular biochemistry and physiology of mammalian protein metabolism.

620. **ADVANCED NUTRITION—ENERGY.**
(3-0) Cr. 3. S.
Prerequisite: B.&B. 406 or equivalent. Young.
Energy constituents of feedstuffs and energy needs of animals as related to cellular biochemistry and physiology. Interpretations of classical and current research.

650. **POPULATION GENETICS.**
(Gen. 650) (3-0) Cr. 3. S.
Prerequisite: Stat. 402. Willham.
Statistical methodology in the study of population genetics. Concepts of a population. Study of qualitative and quantitative population genetics including equilibrium and dynamic populations.

651. **ADVANCED ANIMAL BREEDING I.**
(3-0) Cr. 3. W.
Prerequisite: 650 or equivalent, Stat. 411. Freeman.
Methodology and statistical tools useful in animal breeding theory and application. Correction for environmental effects, estimation and interpretation of components of variance, heritabilities, genetic correlations, and their standard errors. Kinds of selection and selection index theory.

652. **ADVANCED ANIMAL BREEDING II.**
(3-0) Cr. 3. F.
Prerequisite: 651, Stat. 537. Hazel.
Population size, selection intensity, and rate of genetic advance. Conditions for optimum change, genetic limits, and equilibria. Inbreeding, genetic loads, and lethal equivalents in farm animals.

653. **ADVANCED POULTRY BREEDING.**
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: 350. Nordskog.
Survey of poultry genetics. Application of systems of breeding to poultry, including inbreeding, outbreeding, hybridization, and methods of selection.

670. **MOLECULAR BIOLOGY OF MUSCLE.**
(3-0) Cr. 3. Alt. F, offered 1972.
Prerequisite: B.&B. 406 or 503 or permission of instructor; 470 recommended. Goll.
Microstructure and chemical composition of muscle tissue. Chemistry and biosynthesis of muscle and connective tissue protein. Molecular aspects of muscle contraction.

671. **APPLIED MUSCLE BIOLOGY.**
(3-0) Cr. 3. Alt. W, offered 1973.
Prerequisite: 670. Parrish.
Physiological factors affecting muscle properties and rigor mortis. Lipid deposition in muscle. Chemical and physical changes in muscle components and their relationship to muscle as a food. Discussion of currently active research areas.

680. **MODERN VIEWS OF NUTRITION.**
(F.&N. 680) (2-0) Cr. R; W.
A seminar presenting current concepts in nutrition and related fields. Required for all graduate students in nutrition.

699. **RESEARCH.**
A. Animal Breeding.
B. Animal Nutrition.
C. Meat Animal Production.
D. Dairy Production.
E. Meat Science and Muscle Biology.
F. Animal Reproduction.
G. Poultry Breeding.
H. Poultry Nutrition.
I. Poultry Products.

APPLIED ART

Clair B. Watson, M.F.A., Head of Department

The Graduate Faculty

Member: C.B. Watson

Associate Members: H. Adams, G.E. Hamlin, S.E. Held, M.L. Meixner, J.L. Navin

The department offers work for the degree Master of Arts with majors in advertising design, art education, craft design, and interior design. Students taking major work in other departments may take minor work in applied art.

Prerequisite to major graduate work is the completion of undergraduate work in applied art substantially equivalent to that required in the undergraduate curriculum in applied art at this institution.

There is no foreign language requirement for the degree Master of Arts.

For students interested in interdisciplinary study of housing, a program is administered in cooperation with the departments of Applied Art, Architecture, Family Environment, and Landscape Architecture. For details, consult the head of the department.

COURSES FOR GRADUATE STUDENTS, minor only

433. **ADVANCED PAINTING.**
(0-9) Cr. 3. W.S.
Prerequisite: 333.
Emphasis on experimentation in painting.

446. **JEWELRY.**
(0-9) Cr. 3. F.W.S.SSI.
Prerequisite: 247.
Jewelry design.

466. **APPRENTICESHIP.**
Cr. 9. SSI following the junior year.
Prerequisite: 301, 347, 361, 365.
Practical interior design shop experience.

467. **COMMERCIAL INTERIOR DESIGN.**
(1-6) Cr. 3. F.S.
Prerequisite: 365.
Advanced decorative planning; commercial and contract problems.

468. **PROFESSIONAL INTERIOR DESIGN PROCEDURES.**
(2-0) Cr. 2. F.
Prerequisite: Credit or classification in 467.
Written specifications; cost of materials and general procedures for interior designers.

474. **ILLUSTRATION FOR ADVERTISING.**
(0-9) Cr. 3. W.S.
Prerequisite: 370.
Proficiency in media usage. Techniques and styles for illustration.

484. **HISTORY OF ORNAMENT.**
(3-0) Cr. 3. S.
A study of historic ornament with emphasis on the arts of the past and their application to the present.

490. **SPECIAL PROBLEMS.**
Cr. 2 to 3.
Prerequisite: Existing course offerings, reservation, and permission of instructor.
A. Painting and Composition.
B. Textile Design.
C. Weaving.
D. Ceramics.
E. Interior Design.
F. Advertising Design.
G. Fashion Illustration.
J. Jewelry.
K. Design in Wood.
L. Design in Metal and Enamel.
M. Art Education.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

500. SHORT COURSE.
Cr. arr. SSI.
Prerequisite: Permission of instructor.

590. SPECIAL TOPICS.
Cr. arr. F.W.SSI.
Prerequisite: Bachelor's degree in applied art or satisfactory evidence of ability.
A. Painting and Composition.
B. Textile Design.
C. Weaving.
D. Ceramics.
E. Interior Design.
F. Advertising Design.
G. Fashion Illustration.
J. Jewelry.
K. Design in Wood.
L. Design in Metal and Enamel.
M. Art Education.

COURSES FOR GRADUATE STUDENTS, major or minor

605. SEMINAR.
Cr. arr. F.W.S.

699. RESEARCH.

ARCHITECTURE

Martin D. Gehner, M.Arch., Head of Department

The Graduate Faculty

Member: M.D. Gehner

Associate Members: A.E. Burton, T.M. Janowski, K.J. Kocimski, V.F. Stone

The department offers major work for the degree Master of Architecture. The master's program is designed to educate professional architects to work effectively within contemporary constraints, to comprehend continuing changes within our society, and to formulate concepts for a better human environment. Individual study in areas relevant to architecture is encouraged.

Students possessing the degree Bachelor of Arts in architecture should receive the degree Master of Architecture upon successful completion of a minimum of 90 credits of approved graduate studies. Students possessing the five-year degree Bachelor of Architecture should receive the degree Master of Architecture upon successful completion of a minimum of 45 credits of approved graduate studies. A minimum of one academic year of full-time graduate study must be spent in residence at Iowa State University.

There is no foreign language requirement for the degree Master of Architecture.

For students interested in interdisciplinary study of housing, a program is administered in cooperation with the departments of Applied Art, Architecture, Family Environment, and Landscape Architecture. For details consult the head of the department.

COURSES FOR GRADUATE STUDENTS, minor only

321, 322, 323. HISTORY OF ARCHITECTURE I.
(3-0) Cr. 3 each. Yr.
Prerequisite: Hist. 203.
A survey of architecture and the related arts from early western civilization to the modern movement. Architecture as an expression of environment and of social conditions and values is stressed.

361. RESIDENTIAL ARCHITECTURE I.
(3-0) Cr. 3. F.W.
Principles of planning and design of houses with consideration given to site selection, financing, planning, equipment, materials, and methods of construction.

362. RESIDENTIAL ARCHITECTURE II.
(3-0) Cr. 3. W.S.
Prerequisite: 361.
Principles of planning and design of individual unit housing with consideration given to the social, economic and political factors.

363. HOUSING.
(3-0) Cr. 3. F.S.
Prerequisite: 362.
Principles of planning and design of group or multiple housing with consideration given to the social, economic, and political factors.

430. **FREEHAND DRAWING II.**
(0-6) Cr. 2 each time elected. F.W.S.SS.
Prerequisite: Six credits in freehand drawing.
A. Charcoal and crayon.
B. Pencil.
C. Color.
D. Pen and ink.

444, 446, 447. **ARCHITECTURAL TECHNOLOGIES II.**
(M.E. 446, 447) (2-3) Cr. 3 each. Yr.
Prerequisite: 343.
Water supply and sanitation for buildings. Heating, air-conditioning, ventilation. Systems, equipment, controls. Illumination, electrical machinery, power distribution. Systems, equipment, controls. Architectural acoustics. Field trips.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

500. **ARCHITECTURAL INTERNSHIP.**
Cr. R; F.W.S.SS.
Should be taken prior to admission to graduate program.
Prerequisite: Permission of department head.
A one-year cooperative program with an approved architecturally oriented industry or business.

501, 502, 503. **SEMINAR.**
(1-0) Cr. R each. Yr.
Prerequisite: Classification in 514, 515, 516 respectively.
Synthesis, professional orientation, seminar discussion and lectures. Field trips, visiting critics, projects of timely interest.

514, 515, 516. **RESEARCH AND DESIGN III.**
(0-18) Cr. 6 each. Yr.
Prerequisite: 416 or equivalent.
Complex urban architectural design problems. Field trips.

521, 522, 523. **HISTORY OF ARCHITECTURE II.**
(3-0) Cr. 3 each. Yr.
Prerequisite: 323.
A study of architecture and the related arts since the development of the modern movement. Architecture as an expression of environment, social conditions and values.

532. **TWO-DIMENSIONAL DESIGN.**
(0-6) Cr. 2 each time taken. F.W.S.SS.
Prerequisite: Six credits in freehand drawing.
Explorations in the use of expressive forms and spaces through color, value, and textural relationships via the two-dimensional idiom. Primarily in the medium of acrylic and oil paints.

533. **THREE-DIMENSIONAL DESIGN.**
(0-6) Cr. 2 each time taken. F.W.S.SS.
Prerequisite: Six credits in freehand drawing.
Approved student-selected projects. Investigation of contemporary sculptural media.

543. **OFFICE PRACTICE.**
(3-0) Cr. 3. S.
Prerequisite: 343, I.Ad. 365A.
Contract documents, office procedure, and administration.

590. **SPECIAL TOPICS.**
Cr. 2 to 5 each time taken.
Prerequisite: Written approval of instructor and department head.

COURSES FOR GRADUATE STUDENTS, major or minor

611, 612, 613. **RESEARCH AND DESIGN IV.**
(0-21) Cr. 7 each. Yr.
Prerequisite: 516.
Individual and group solutions to large scale architectural problems of complex, multiple or specialized requirements. Student competitions. Field trips.

681, 682, 683. **THEORY OF URBAN ARCHITECTURE.**
(2-0) Cr. 2 each. Yr.
Prerequisite: 523.
History, theory, and problems relating to the determinants of urban architecture.

BACTERIOLOGY

William R. Lockhart, Ph.D., Chairman of Department

The Graduate Faculty

Members: D.P. Durand, L.R. Frederick, P.A. Hartman, W.R. Lockhart, P.A. Pattee, G.W. Reinbold, L.Y. Quinn, H.W. Walker

Associate Members: J.G. Holt, F.D. Williams

The department offers work for the degrees Master of Science and Doctor of Philosophy with major in bacteriology. Within the major the student may specialize in pathogenic bacteriology and immunology, food and sanitary bacteriology, agricultural and industrial microbiology, physiology and genetics of bacteria, virology, and systematic bacteriology. Major graduate study in veterinary bacteriology, soil bacteriology, and dairy bacteriology is offered in the departments of Veterinary Microbiology, Agronomy, and Food Technology, respectively.

Specific prerequisite to major work in bacteriology is the completion of thorough courses in general bacteriology, biology, organic chemistry, and physics. Biochemistry, physical chemistry, and mathematics are advised. Minor study usually is selected from chemistry, biochemistry and biophysics, botany, zoology, genetics, mathematics and statistics.

Major and minor work in the area of cell biology is offered under a cooperative arrangement with the departments of Bacteriology, Biochemistry and Biophysics, Botany and Plant Pathology, Genetics, and Zoology and Entomology. See *Cell Biology*.

Candidates for the M.S. degree must demonstrate their ability to translate scientific articles from either French, German, or Russian, and Ph.D. candidates must demonstrate ability to translate material from two of the foregoing languages. Language examinations are administered by the department. Before the first such examination, a student must either have completed two years of formal study of the language in question, with grades averaging at least B, or earn a score of at least 400 in the Educational Testing Service Foreign Language Examination. Ordinarily this requirement will be satisfied before enrollment in the Graduate College. The manner in which the requirement for the second language is met may vary according to the needs of the individual student.

COURSES FOR GRADUATE STUDENTS, minor only

412. **FOOD PRESERVATION.**
(F.Tch. 412) See Food Technology.

413. **MICROORGANISMS IN FOODS.**
(3-0 or 3-6) Cr. 3 or 5. W.
Prerequisite: 300.
The normal microbial flora of foods; food infections and intoxications; microbiological indicators of contamination of foods.

414. **FOOD, MILK, AND WATER SANITATION.**
(F.Tch. 414) See Food Technology.

450. **DAIRY MICROBIOLOGY.**
(F.Tch. 450) See Food Technology.

485. **AGRO-MICROBIOLOGY.**
(Agron. 485) See Agronomy.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

509. **GENERAL VIROLOGY.**
(Bot. 509, V.Micr. 509)
(3-0) Cr. 3. F.
Prerequisite: Permission of instructor.
Bacterial, plant, and animal viruses with special reference to morphology, physical-chemical properties, multiplication, and host responses.

525. **APPLIED MICROBIOLOGY.**
(3-0) Cr. 3. F.
Prerequisite: 300.
Utilization of microorganisms in agriculture and industry.

575. **IMMUNOLOGY.**
(Imbio. 575) (3-6) Cr. 5. S.
Prerequisite: 300.
Theories of immunity and immunization; preparation of vaccines and antisera; antigen-antibody reactions.

585. **SOIL MICROBIOLOGY AND BIOCHEMISTRY.**
(Agron. 585) See Agronomy.

COURSES FOR GRADUATE STUDENTS, major or minor

601, 602, 603. **ADVANCED BACTERIOLOGY.**
(3-6) Cr. 5 each. Yr.
Prerequisite: 601: Permission of instructor; 602: 601; 603: 602.
601: Bacterial nutrition; metabolic and genetic control of cell function; influence of physical and chemical environment on bacteria. 602: Metabolism, biosynthetic and catabolic pathways; methods for study of metabolic pathways. 603: Morphology and cytology of the major groups of bacteria; principles governing the classification of bacteria.

610. **SPECIAL TOPICS.**
Cr. 2 to 5.
Prerequisite: Permission of instructor.
Selected topics of current interest.

615. **MOLECULAR VIROLOGY.**
(3-6) Cr. 5. S.
Prerequisite: 509 or 603.
Structure, function, and genetics of viruses and virus-like agents; host-virus interactions.

620. **MOLECULAR GENETICS.**
(Gen. 620) See Genetics.

621. **BACTERIAL GENETICS.**
(Gen. 621) (3-6) Cr. 5. F.
Prerequisite: 603.
Isolation, characterization, and uses of mutant bacteria; mechanisms of genetic exchange and their application to genetic and biochemical analysis of bacteria.

645. **BACTERIAL CYTOLOGY.**
(3-3) Cr. 4. Alt. W, offered 1973.
Prerequisite: 603.
Chemical and physical structure of the bacterial cell; methods in microscopy of bacteria.

656. **ADVANCED FOOD MICROBIOLOGY.**
(F.Tch. 656) See Food Technology.

660. **SYSTEMATIC BACTERIOLOGY.**
(3-3) Cr. 4. Alt. W, offered 1972.
Prerequisite: 603.
Theories of classification; applications of molecular and numerical data; principles of bacteriological nomenclature.

675. **ADVANCED IMMUNOLOGY.**
(Imbio. 675) (3-6) Cr. 5. Alt. F, offered 1972.
Prerequisite: 575.
Principles and methods of immunochemistry, immunogenetics, and immunocytology.

678. **TISSUE CELL CULTURE RESPONSES TO PATHOGENS.**
(3-6) Cr. 5. Alt. F, offered 1971.
Prerequisite: 603.
Methods for tissue cell culture propagation; measurement of tissue cell culture metabolism; comparison of pathogen-free and infected cultures.

698. **SEMINAR IN CELL BIOLOGY.**
(C.Bio. 698) See Cell Biology.

699. **RESEARCH.**

BIOCHEMISTRY AND BIOPHYSICS

Jack Horowitz, Ph.D., Chairman of Department

The Graduate Faculty

Members: J.B. Applequist, E.W. Bird, J.M. Bremner, P.A. Dahm, J.G. Foss, D. French, H.J. Fromm, D.E. Goll, D.J. Graves, W.R. Hearn, R.L. Heintz, J. Horowitz, J.D. Imsande, D.E. Metzler, D.E. Outka, P.A. Rebers, J.F. Robyt, H.E. Snyder, B.H. Thomas, C.L. Tipton, W.C. Wildman

Associate Members: A.G. Atherly, D.C. Beitz, M.A. Rougvie, J.A. Thomas, C.M. To, B.J. White

The department offers work for the degrees Master of Science and Doctor of Philosophy with majors in biochemistry and in biophysics and minor work to students taking major work in other departments.

Major and minor work in the area of cell biology is offered under a cooperative arrangement with the departments of Bacteriology, Biochemistry and Biophysics, Botany and Plant Pathology, Genetics, and Zoology and Entomology. See *Cell Biology.*

Prerequisite to graduate work is completion of sufficient undergraduate work in chemistry, mathematics, physics, and biology.

There is no foreign language requirement for the degree Master of Science. Candidates for the degree Doctor of Philosophy must demonstrate a reading knowledge of one foreign language, chosen from French, German, or Russian, by passing (50th percentile or better) the Educational Testing Service examination. A foreign student whose native language is Chinese, French, German, Italian, Japanese, Russian, or Spanish may be excused from the foreign language examination.

COURSES FOR GRADUATE STUDENTS, minor only

304, 305. **PHYSIOLOGICAL CHEMISTRY.**
(3-0) Cr. 3 each. 304: F ; 305: W.
Prerequisite: Chem. 335.
304: Chemistry of the animal body; digestion; absorption. 305: Metabolism of carbohydrates, lipids, proteins, and minerals.
Must be accompanied by 314 and 315 for veterinary medicine students. Not accepted for credit toward a chemistry, biochemistry, or biophysics major.

401. **PRINCIPLES OF BIOCHEMISTRY.**
(4-0) Cr. 4. S.
Prerequisite: Classification or credit in Chem. 333 or 335; Phys. 113 or 223.
A qualitative but rigorous introduction to biochemistry, with emphasis on the cellular and subcellular aspects. Topics include: energy transductions, metabolism, biopolymers, enzymes, organelles, and regulatory mechanisms. For undergraduate physical, biological, or engineering science majors.

404, 405, 406. BIOCHEMISTRY.
(3-0) Cr. 3 each. Yr.
Prerequisite: Chem. 335 or equivalent; Chem. 336 recommended.
A general biochemistry course intended primarily for students in biology, agriculture, and home economics, emphasizing intermediary metabolism and the biochemistry of higher organisms. 404 and 405: Catalysis, bioenergetics, chemistry of biological materials, intermediary metabolism and synthesis of biopolymers. 406: Metabolism of differentiated cells; membranes and cell walls; biosynthesis of metalloporphyrins and other prosthetic groups, cofactors and vitamins; and other topics.

461. INTRODUCTION TO BIOPHYSICS.
(3-0) Cr. 3. F.
Prerequisite: Chem. 115 or 142 or 148, Phys. 113 or 223.
Ideas and methods used in biophysics to attack fundamental biological problems. A study of several currently active research areas such as molecular genetics, contractility, nerve conduction and vision.

490. SPECIAL PROBLEMS.
Cr. arr.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

501, 502, 503. GENERAL BIOCHEMISTRY.
(4-0) Cr. 4 each. Yr.
Prerequisite: Courses in analytical chemistry, organic chemistry (Chem. 333 or 335) and physical chemistry (Chem. 322 or 325 or 494). Concurrent enrollment in physical chemistry may be permitted with consent of instructor.
Chemical composition of living matter and the chemistry of life processes. For graduate students in biochemistry and biophysics, and advanced undergraduates in chemistry and for other qualified students desiring a rigorous course.

511, 512. LABORATORY IN GENERAL BIOCHEMISTRY.
(1-6) Cr. 3 each. 511: F ; 512: W.
Prerequisite: 511: 401 or 405 or 501 or concurrent registration in 501; 512: 511.
Modern techniques of biochemical research.

521. RADIOBIOCHEMISTRY.
(1-6) Cr. 3. W.S.
Prerequisite: Chem. 426, permission of instructor. Heintz, White.
A laboratory course in the use of radioisotopes in biochemistry; dilution techniques, isolation of metabolites, elucidation of reaction mechanisms, and metabolic pathways.

527, 528. ADVANCED CELL BIOLOGY.
(C.Bio. 527, 528) See Cell Biology.

561, 562. BIOPHYSICAL METHODS.
(3-0) Cr. 3 each. 561: W; 562: S.
Prerequisite: Fundamental training in biology, physics, calculus, organic and physical chemistry, permission of instructor. Foss, Rougvie.
Optical techniques: spectroscopy and spectrophotometry, birefringence, optical rotation, light scattering, etc. Methods for the study of macromolecules: viscosity, diffusion, ultracentrifugation, electrophoresis, X-ray diffraction.

571, 572. LABORATORY IN BIOPHYSICS.
(0-6) Cr. 2 each. 571: W; 572: S.
Prerequisite: Permission of instructor. Foss, Rougvie.
To accompany 561, 562.

574. MICROSCOPY.
(3-0) Cr. 3. S.
Prerequisite: Permission of instructor. Outka, To.
Optical microscopy including phase and interference techniques. Principles of electron optics. Methods and applications of electron microscopy.

575. LABORATORY IN MICROSCOPY.
(0-6) Cr. 2. S.
Prerequisite: Credit or classification in 574. Outka, To.

581, 582. SEMINAR.
(1-0) Cr. 1 each. 581: F; 582: W.
Prerequisite: Permission of instructor.
Short talks and discussion by students on assigned topics. For entering graduate students and qualified seniors.

590. SPECIAL TOPICS.
Cr. arr.

COURSES FOR GRADUATE STUDENTS, major or minor

601. ADVANCED BIOCHEMISTRY.
(2-0) Cr. 2 each time taken. F.W.S.
Prerequisite: 501, permission of instructor.
A series of one term courses covering topics such as enzymes, hormones, lipids, nucleic acids, proteins, vitamins, biochemistry of diseases, immunochemistry, and biochemical methods.

622. CARBOHYDRATE CHEMISTRY.
(3-0) Cr. 3. SS. French.
Prerequisite: Permission of instructor.
Chemical behavior and enzymic relationships of sugars and polysaccharides.

661. ADVANCED BIOPHYSICS.
(3-0) Cr. 3 each time taken. F.
Prerequisite: Permission of instructor.
Study of topics in biophysical research such as molecular genetics, muscle contraction and motility, nerve conduction, vision, hearing, photosynthesis, fine structure of biological systems, radiation biology, new or advanced techniques, and macromolecular physics and chemistry.

681. ADVANCED SEMINAR.
(1-0) Cr. 0. F.W.S.

698. SEMINAR IN CELL BIOLOGY.
(C.Bio. 698) See Cell Biology.

699. RESEARCH.
Prerequisite: Permission of staff member concerned.

BIOLOGY

Biology encompasses a number of departments at Iowa State University. Basic undergraduate and graduate courses and research opportunities in the biological sciences are offered in the departments of Bacteriology, Biochemistry and Biophysics, Botany and Plant Pathology, Genetics, and Zoology and Entomology. Proper selection of courses from these departments and appropriate choices in mathematics, physics, and chemistry provide an excellent foundation for an understanding of biological phenomena, concepts, and methods of investigation. In addition, the departments of Agronomy, Animal Science, Child Development, Food and Nutrition, Food Technology, Forestry, Horticulture, and Psychology; departments within the College of Veterinary Medicine; and majors in biomedical engineering, diary science, farm crops, and fisheries and wildlife biology provide undergraduate and graduate instruction and research programs in applied and specialized phases of the biological sciences.

The undergraduate program in biology (see *General Catalog*) provides broad preparation for graduate work in the biological sciences, and offers opportunities for graduate students to gain teaching experience in a modern approach to biology.

Persons interested in graduate study in biology may take Master of Science and Doctor of Philosophy degrees with a major in any of the life science disciplines. Interdepartmental graduate programs in cell biology, general science, immunobiology, and water resources are also available.

Secondary school biology teachers who wish to broaden and update their formal training in biology may pursue graduate work in the life sciences under the Master of Science program in general science. (See *General Science.*)

BIOMEDICAL ENGINEERING

Neal R. Cholvin, D.V.M., Ph.D., Chairman

The Graduate Faculty

Members: N.R. Cholvin, D.D. Gillette, P.T. Pearson, R.C. Seagrave, D.F. Young

Associate Members: D.L. Carlson, W.H. Brockman, R.L. Engen, J.H. Magilton, A.G. Potter, C.S. Swift, G.A. VanGelder

Work is offered for the degrees Master of Science and Doctor of Philosophy with major in biomedical engineering, and minor work for students taking major work in other areas. Prerequisite to major and minor work in biomedical engineering is an undergraduate degree in one of the fields of engineering, life sciences, physical sciences, or a professional degree in one of the fields of medicine. Depending upon the individual's background, the major student will usually elect minor work in at least one of the following curricula: biochemistry and biophysics, chemical engineering, computer science, electrical engineering, engineering mechanics, mathematics, mechanical engineering, veterinary anatomy, veterinary clinical sciences, veterinary physiology, psychology, or zoology. All students are encouraged to obtain previous background knowledge of organic chemistry, calculus, beginning differential equations, and physics. Candidates for the degree Doctor of Philosophy will be required to demonstrate proficiency in one modern foreign language. For the degree Master of Science there is no language requirement.

The program of formal courses taken by students will be oriented toward developing proficiency in research in the interdisciplinary field. Selected background as well as advanced course work from other related disciplines will be taken in conjunction with appropriate biomedical engineering course topics. The program of formal courses will vary, depending upon the background and interests of the student, and will be determined in consultation with the student's advisory committee.

In addition to the courses described later, the following courses are recognized to have strong bearing on studies in biomedical engineering:

B.&B. 561, 562, 661
Ch.E. 520, 554, 555, 556, 631, 632, 633
C.E. 418, 510, 516
Com.S. 447, 451, 452, 453, 484
E.E. 441, 445, 507, 508, 509, 565, 584, 677, 678
E.M. 420, 504, 505, 506, 514, 517, 544, 548, 571, 630
Nuc. E. 684
Math. 521, 522, 523
V.An. 510, 511
V.Phys. 510, 512, 513, 661
Zool. 650

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

521. **ELECTRICAL CIRCUITS FOR BIOMEDICAL ENGINEERING.**
(2-0) Cr. 2. W.
Prerequisite: E.E. 441, credit or classification in E.E. 445.
Introduction to concepts of frequency response, bridge circuits, and transformers.

522. **ELECTRICAL CIRCUITS AND SYSTEMS FOR BIOMEDICAL ENGINEERING.**
(3-3) Cr. 4. S.
Prerequisite: 521, E.E. 445.
Analysis and synthesis of electronic instrumentation and systems for biomedical engineering. Differential and DC amplifiers, electrical noise and filters, feedback, and stability.

535. **BIOMEDICAL APPLICATIONS OF HEAT AND MASS TRANSFER.**
(3-0) Cr. 3. W.
Prerequisite: 561, E.M. 420.
The principles of heat and mass transfer applied to biomedical problems. Applications in the study of physiology and in the design and operation of artificial organs.

561, 562, 563. **COMPARATIVE MAMMALIAN ANATOMY AND PHYSIOLOGY.**
(V.An. 561, 562, 563) (V.Phys. 561, 562, 563) 561: (3-3) Cr. 4. F; 562: (4-3) Cr. 5. W; 563: (3-3) Cr. 4. S.
Prerequisite: 561: Credit or classification in B.&B. 304; 562: 561, credit or classification in B.&B. 305; 563: 562.
Integrated teaching approach for graduate students who have had little or no previous training in anatomy and physiology. Designed for students in animal nutrition, biochemistry, engineering, food and nutrition, psychology, and other biological sciences. 561: Cellular structure and function, nervous system, sensory systems, muscle systems. 562: Cardiovascular system, respiration, acid-base balance, excretion. 563: Digestion, metabolism, reproduction, and endocrine systems.

571. **THEORY AND TECHNIQUES OF BIOLOGICAL INSTRUMENTATION.**
(3-0) Cr. 3. W.
Prerequisite: 563, Math. 321.
Characteristics of biological signals, transducers, error and artifact suppression, biological data acquisition and processing systems.

572. **SIMULATION OF BIOLOGICAL SYSTEMS.**
(3-3) Cr. 4. F.
Prerequisite: 522, 563, Math. 321.
Theory and operation of analog computers. Development of mathematical models for biological control systems and application of analog computers to the simulation of these systems.

590. **SPECIAL TOPICS.**
Cr. 1 to 5 as arranged.
Prerequisite: Permission of instructor.
Investigation of problems of special interest in biomedical engineering.

593. **ADVANCED BIOLOGICAL SYSTEM SIMULATION.**
(3-0) Cr. 3. W.
Prerequisite: 572.
Selected simulation topics of current interest in biomedical engineering.

COURSES FOR GRADUATE STUDENTS, major or minor

600. **SEMINAR.**
(1-0) Cr. 1. As arr.

661. **BIOMEDICAL DATA PROCESSING.**
(3-0) Cr. 3. Alt. S, offered 1973.
Prerequisite: 522.
Digital data acquisition systems used in biomedical research, hardware, data reduction algorithms, digital filters.

665. **INFORMATION PROCESSING IN LIVING SYSTEMS.**
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: 522.
Nervous and neuron network models, information processing in living systems, artificial intelligence and pattern recognition.

699. **RESEARCH.**

BOTANY AND PLANT PATHOLOGY

Frederick G. Smith, Ph.D., Head of Department

The Graduate Faculty

Members: I.C. Anderson, C.C. Bowen, J.A. Browning, J.D. Dodd, J.M. Dunleavy, R.E. Ford, H.T. Horner, Jr., D. Isely, N.R. Lersten, H.S. McNabb, D.J. Nevins, D.C. Norton, R.W. Pohl, M.D. Simons, F.G. Smith, D.W. Staniforth, L.H. Tiffany, J.R. Wallin

Associate Members: J.S. Burris, A.H. Epstein, D.C. Foley, R.G. Franke, C.E. LaMotte, R.Q. Landers, C.A. Martinson, C.R. Stewart, R.B. Wildman, J.W. Wooten

The department offers work for the degrees Master of Science and Doctor of Philosophy with majors in botany and plant pathology, and minor work for students majoring in other departments. Within the botany major the student may specialize in aquatic plant biology, cytology, ecology, economic botany, morphology, mycology, physiology, and taxonomy. A Master of Science nonthesis option is available.

Major and minor work in the area of cell biology is offered under a cooperative arrangement with the departments of Bacteriology, Biochemistry and Biophysics, Botany and Plant Pathology, Genetics, and Zoology and Entomology. See *Cell Biology*. The department is also a cooperating department in the water resources program. See *Water Resources*.

Students entering graduate programs in the department should have a broad liberal science background which includes basic coursework in the physical sciences and mathematics, as well as the biological sciences.

There is no foreign language requirement for the degree Master of Science. For the degree Doctor of Philosophy, the minimum requirement is one language, ordinarily German, French, or Russian. The requirement may be met by a passing score on the Education Testing Service examination, by presenting a minimum of six quarters or four semesters of B credits of college-level work in an approved language, or by passing a departmental translation examination.

Students majoring in botany usually select minors from agronomy, bacteriology, biochemistry and biophysics, chemistry, forestry, genetics, geology, horticulture, physics, or zoology and entomology.

COURSES FOR GRADUATE STUDENTS, minor only

320. PLANT PHYSIOLOGY.
(3-6) Cr. 5. S.
Prerequisite: 107; Chem. 334 or B.&B. 301.
Application of elementary physical and biological principles to the understanding of plant processes involved in assimilation, metabolism, and regulation of growth and development. Experimental approach emphasized. Credit toward graduation is not allowed for both 310 and 320.

404. PLANT ANATOMY.
(2-6) Cr. 4. F.W.SSI or II.
Prerequisite: 107. Lersten.
Structure and development of vegetative and reproductive organs of vascular plants, with emphasis on angiosperms. Includes introduction to basic microtechnique.

407. PRINCIPLES OF PLANT PATHOLOGY.
(2-4) Cr. 4. W.S.
Prerequisite: 310 or 320.
Principles underlying the nature and control of plant diseases.

410. FUNDAMENTALS OF BOTANY.
(3-4) Cr. 5. S.
Prerequisite: Fifteen credits in physical science. Knaphus, LaMotte.
Study of plant forms and functions with approximately equal emphasis on morphological-evolutionary and on physico-chemical aspects of botany.

416. FOREST PATHOLOGY.
(For. 416) (2-6) Cr. 4. S.
Prerequisite: 310 or 320. McNabb.
Nature and control of forest and shade tree diseases. Weekend field trips in northern and eastern Iowa. For satisfactory-fail credit only.

417. WOOD DETERIORATION.
(For. 417) (2-6) Cr. 4. Alt. W, offered 1973.
Prerequisite: 310 or 320. McNabb.
Decay and stains of wood, including forest product pathology. Field trips to local woods and lumber yards. For satisfactory-fail credit only.

424. GENERAL PLANT ECOLOGY.
(2-3) Cr. 3. F.S.SSI.
Prerequisite: 203 or 306; Biol. 103 or Agron. 315 or For. 301. Landers.
Vegetation structure and function in relation to environment; classification; community dynamics; management of vegetation demonstrated by local field trips; ecosystem viewpoints. May be taken at Iowa Lakeside Laboratory with written permission of instructor.

428. CELL BIOLOGY.
(C.Bio. 428) See Cell Biology.

438. SEED BIOLOGY.
(Agron. 438) (2-2) Cr. 3. W.
Prerequisite: 310 or 320. Burris.
Physiological aspects of seed development, maturation, longevity, and germination; ecological and agricultural implications of seed biology.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

500. **FRESHWATER ALGAE.**
(3-3) Cr. 4. F. (SSI. Lakeside Lab.)
Prerequisite: Fifteen credits in biological science. Dodd.
Role of algae in freshwater habitats; environmental factors affecting growth and distribution; basic procedures for collecting, identifying, and enumerating. Field trips. May be taken at Iowa Lakeside Laboratory with written permission of instructor.

505. **MORPHOLOGY OF GREEN PLANTS.**
(3-6) Cr. 5. S.
Prerequisite: Fifteen credits in biological science including 107. Farrar.
Significant evolutionary trends in algae, bryophytes, and vascular plants and their relation to modern concepts of phylogeny.

506. **PRINCIPLES OF MYCOLOGY.**
(2-6) Cr. 4. F.
Prerequisite: Fifteen credits in biological science. Tiffany.
Morphology, cytology, and physiology of fungi; their relation to agriculture and industry.

509. **GENERAL VIROLOGY.**
(Bact. 509) See Bacteriology.

511. **PLANT NUTRITION.**
(3-0) Cr. 3. F.
Prerequisite: 320, Phys. 112, Chem. 335. LaMotte, Nevins, Stewart.
Mineral nutrition, water relations, and translocation in vascular plants.

512. **PLANT GROWTH REGULATION.**
(3-0) Cr. 3. W.
Prerequisite: 320, Chem. 335. LaMotte.
Vascular plant growth, correlative phenomena in development, and hormones involved in their regulation.

513. **PLANT METABOLISM.**
(3-0) Cr. 3. S.
Prerequisite: 320, Phys. 112, Chem. 335. Nevins, Stewart.
Photosynthesis, respiration and other aspects of metabolism in plants.

514. **PLANT MORPHOGENESIS.**
(3-0) Cr. 3. S.
Prerequisite: 404, 512. Horner, LaMotte.
Causal mechanisms underlying patterns of development.

517. **PHYSIOLOGICAL METHODS AND TECHNIQUES.**
(0-6 or 9) Cr. 2 or 3. F.
Prerequisite: Credit or classification in 511 or 512 or 513. Nevins.
Research methods and techniques in plant physiology. Permission of instructor required for 2-credit option.

527, 528. **ADVANCED CELL BIOLOGY.**
(C.Bio. 527, 528) See Cell Biology.

541. **DISEASES OF ECONOMIC PLANTS.**
(3-3) Cr. 4. F.
Prerequisite: 407.
Plant diseases caused by bacteria, fungi, nematodes, and viruses. For students not majoring in plant pathology.

558. **PALEOBOTANY.**
(2-3) Cr. 3. Alt. W, offered 1972.
Prerequisite: Permission of instructor. Farrar.
Introduction to the morphology, relationships, and identification of fossil plants. Field trips.

564. **AQUATIC PLANTS.**
(2-6) Cr. 4. F.
Prerequisite: 306. Wooten.
Taxonomy, ecology, and morphological specializations of aquatic plants, with emphasis on vascular plants. Field trips.

574. **PLANT NEMATOLOGY.**
(3-3) Cr. 4. F.
Prerequisite: 407 or 416 or 417. Norton.
Morphology, anatomy, and life cycles of commonly encountered plant-parasitic nematodes; symptom expression; control; concepts.

575. **FIELD MYCOLOGY.**
(2-6) Cr. 4 each time taken. SSI. 1973. (SSII. 1972. Lakeside Lab.)
Prerequisite: Nine credits in botany. Tiffany.
Collection and taxonomy of fungi and relation of their occurrence to environmental factors. Preparation and utilization of mycological exsiccati. Field trips. May be taken at Iowa Lakeside Laboratory with written permission of instructor.

584. **ADVANCED PLANT ECOLOGY.**
(2-3) Cr. 3. F.
Prerequisite: 424. Landers.
Theories and approaches to the study of vegetation from Clements to the most recent authors; plant succession and community stability. Field trips.

590. **SPECIAL TOPICS.**
Cr. 2 to 5 each time taken.
Prerequisite: Fifteen credits in botany, permission of instructor.
A. Morphology.
B. Physiology.
C. Plant Pathology.
D. Mycology.
E. Taxonomy.
F. Plant Ecology.
G. Economic Botany.
J. Cytology.
K. Aquatic Plant Biology.

591. **ADVANCED GENERAL PLANT PATHOLOGY.**
(4-3) Cr. 5. F.
Prerequisite: 404, 407, 506, 509, 574; 511 or 512 or 513, Bact. 300, Gen. 301 or 350, and credit or classification in Stat. 401.
Representative plant diseases, plant disease concepts and processes, and literature review.

592. **HOST-PARASITE INTERACTIONS.**
(4-3) Cr. 5. Alt. W, offered 1972.
Prerequisite: 591.
Physiological and morphological aspects of plant disease.

593. **EPIPHYTOLOGY.**
(4-3) Cr. 5. Alt. W, offered 1973.
Prerequisite: 591, Stat. 402.
Study of interactions between and among host populations, parasite populations, and the environment.

594. **PHYTOGEOGRAPHY.**
(0-6 and two weekend field trips.) Cr. 3. F.
Prerequisite: Fifteen credits of biological science, including Bot. 306; historical geology recommended. Pohl.
History and nature of the principal vegetational formations, particularly of North America. Origins of vascular flora; the Arcto-tertiary flora; tertiary floras of the eastern and western U.S.; origins of grassland and desert floras; Pleistocene and recent floristic history of the North American vegetation.

595. **AGROSTOLOGY.**
(2-4) Cr. 4. W.
Prerequisite: 306. Pohl.
Morphology, classification, and identification of grasses; utilization of grasses in agriculture and grazing.

COURSES FOR GRADUATE STUDENTS, major or minor

601. ADVANCED MORPHOLOGY.
(2-0) Cr. 2 each time taken. F.W.S.
Prerequisite: 505.
Special topics in major plant groups. Reading, discussions, oral and written term papers.

605. CYTOGENETICS.
(Gen. 605) See Genetics.

624. PHYSIOLOGY OF FUNGI.
(3-0) Cr. 3. Alt. W, offered 1972.
Prerequisite: 506. Smith.
Special physiology of fungi; nutrition, metabolism, growth, and toxicology.

629. FINE STRUCTURE OF PLANT CELLS.
(3-0) Cr. 3. S.
Prerequisite: 404; C.Bio. 428 or 528. Horner and Wildman.
Structure and function of cells and cellular components at various levels of evolutionary development.

641, 642, 643. GENERAL MYCOLOGY.
(2-6) Cr. 4 each. Yr.
Prerequisite: 407 or 416 or 417. Tiffany.
Taxonomy, morphology, and phylogeny of slime molds and fungi (phycomycetes, ascomycetes, fungi imperfecti, and basidiomycetes).

646. ANIMAL MYCOLOGY.
(0-6) Cr. 3. Alt. W, offered 1972.
Prerequisite: 506. Tiffany.
Morphology, cytology, and physiology of fungi causing animal mycoses; includes superficial mycoses, dermatomycoses, and systemic mycoses.

679, 680. MICROSCOPY I AND II.
(2-9) Cr. 5 each. 679:F; 680: W.
Prerequisite: 679: 310 or 320, 404, permission of instructor; 680: 679. Horner.
Current theories and methods encompassing light and electron microscopy. Chemical and physical preparations of specimens, qualitative and quantitative cytochemistry and histochemistry, autoradiography, microphotography, and ancillary techniques.

690. ADVANCED PLANT TAXONOMY.
(2-3) Cr. 3. S.
Prerequisite: 306; Gen. 301 or 350. Isely.
Literature and philosophy of plant classification, processes of speciation in higher plants, sources and interpretation of data, research methods, and plant nomenclature.

691. ADVANCED PLANT PATHOLOGY.
(2-0 or 0-6) Cr. 2 each time taken.
Prerequisite: Permission of instructor.
A. Diseases Caused by Bacteria. Alt. W, offered 1972. Dunleavy.
B. Plant Nematology. Alt. W, offered 1973. Norton.
C. Forest Tree Diseases. Alt. F, offered 1971. McNabb.
D. Laboratory in Virology. Alt. S, offered 1972. Ford.
E. Toxicology. Alt. S, offered 1973.
F. Clinical Diagnosis. SS.
G. Soil-borne Plant Pathogens. Alt. S, offered 1973. Martinson.
H. Use of Host-resistant Genes. Alt. W, offered 1972. Browning.

698. SEMINAR.
Meetings of botany staff and students to discuss recent literature and problems under investigation.
A. **Cr. 1. F.S.**
For students taking major work in morphology and taxonomy.
B. **Cr. 1. F.S.**
For students taking major work in physiology.
C. **Cr. 1. F.S.**
For students taking major work in plant pathology.
D. **Cr. 1. W.**
For all staff and students in botany and plant pathology.
E. Cell biology. **S.** (C.Bio. 698)
See Cell Biology.
F. **Cr. 1. F.S.**
For students taking major work in ecology.

699. RESEARCH.
A. Morphology.
B. Physiology.
C. Plant Pathology.
D. Mycology.
E. Taxonomy.
F. Plant Ecology.
G. Economic Botany.
J. Cytology.
K. Aquatic Plant Biology.

*COURSES OFFERED AT THE IOWA LAKESIDE LABORATORY

424L. (L:120) GENERAL PLANT ECOLOGY.
(8-24) Cr. 8. SSII.
Prerequisite: 203 or 306; Biol. 103 or Agron. 315 or For. 301.
Vegetation structure and function in relation to environment; classification; community dynamics; management of vegetation demonstrated by local field trips; ecosystem viewpoints.

500L. (L:109) ALGOLOGY.
(8-24) Cr. 8. SSI.
Prerequisite: Fifteen credits in biological science.
Identification and morphological study of algae with special reference to the fresh-water algae of the midwest. Field trips.

575L. (L:105) FIELD MYCOLOGY.
(8-24) Cr. 8. SSII, offered 1972.
Prerequisite: Nine credits in botany.
Collection and taxonomy of fungi and relation of their occurrence to environmental factors. Preparation and utilization of mycological exsiccati. Field trips.

579X L. (L:117) ECOLOGY AND SYSTEMATICS OF DIATOMS.
(8-24) Cr. 8. SSII.
Prerequisite: Fifteen credits in biological science.
Field experience in the study of fresh-water diatoms. Environmental factors affecting growth and distribution are stressed. Techniques, collection, and preparation of diatom samples.

579Y L. (L:105) FIELD BIOLOGY OF ANGIOSPERMS. (8-24) Cr. 8. SSII.
Prerequisite: Fifteen credits in biological science. Field and laboratory study of local flowering plant populations, synthesizing the evolutionary, systematic, and ecological approaches. Methods of collecting, sampling, analyzing, and recording information; individual and group projects. For students with background in genetics and taxonomy.

590. **SPECIAL TOPICS.**
(See preceding section.)

699. **RESEARCH.**
(See preceding section.)

*Written permission of the instructor is prerequisite to all courses offered at the Iowa Lakeside Laboratory. For current information concerning courses, registration, and housing, see the annual Iowa Lakeside Laboratory Bulletin. This bulletin is usually available from participating departments after February 15. Numbers beginning with L indicate numbers used by the University of Iowa.

CELL BIOLOGY

C.C. Bowen, Ph.D., Chairman, Advisory Committee

Advisory Committee: Alan G. Atherly, Ph.D.; Darrel E. Goll, Ph.D.; Darryll E. Outka, Ph.D.; Peter A. Pattee, Ph.D.; James R. Redmond, Ph.D.

Work is offered for the degrees Master of Science and Doctor of Philosophy with major in cell biology under an interdepartmental cooperative arrangement; minor work is offered to students taking major work in other areas. Facilities exist in the several departments for fundamental research in such areas as electron microscopy of cells, their chemistry and physiology particularly in relation to molecular architecture, cellular mechanisms in heredity and radiation response, and the special cytology of bacteria, algae, fungi, protozoa and higher organisms.

A student majoring in cell biology will choose a major professor from the graduate faculty membership of the cooperating departments and will develop his program of study under the guidance of an advisory committee nominated by the coordinating committee and appointed by the Dean of the Graduate College.

For the Master of Science degree, competency in one foreign language is required, as demonstrated by an ETS proficiency rating of at least the 25th percentile or at least comparable proficiency as demonstrated to the satisfaction of the student's advisory committee. The language requirement for the Ph.D. degree may be met in either of the following ways: (1) One language with an ETS proficiency rating of the 25th percentile or above, or at least comparable proficiency in that language as demonstrated to the satisfaction of the student's advisory committee, plus either a second language at the same proficiency level or successful completion of a substantial additional requirement as directed by the student's committee; or (2) One language with an ETS proficiency rating in the 50th percentile or above, or at least comparable proficiency in that language as demonstrated to the satisfaction of the student's advisory committee.

The following is a partial listing of courses that relate directly to cell biology: Bact. 645; B.&B. 574 and 575; Bot. 629, 679, and 680; Gen. 605; Zool. 529, 627, and 650.

COURSE FOR GRADUATE STUDENTS, minor only

428. CELL BIOLOGY.
(Biol. 428, Bot. 428, Zool. 428) (3-0 or 3-3) Cr. 3 or 4. F.
Prerequisite: Fifteen credits in the biological sciences; organic chemistry. Permission of instructor required for enrollment in laboratory.
Viles.
Biological organization and function at the cellular level.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

527, 528. ADVANCED CELL BIOLOGY.
(B.&B. 527, 528; Bot. 527, 528; Zool. 527, 528)
(3-6) Cr. 5 each. 527: F; 528: W.
Prerequisite: 527: Permission of instructor; 528: 527. Bowen, Outka, Viles.
Structure and function of cytoplasm and nucleus; molecular architecture of intracellular differentiation.

590. SPECIAL TOPICS.
(2-0) Cr. 2 each time taken.
Prerequisite: Permission of instructor.
Current frontier areas in cell biology.

COURSES FOR GRADUATE STUDENTS, major or minor

698. SEMINAR IN CELL BIOLOGY.
(Bact. 698, B.&B. 698, Bot. 698E, Gen. 698, Zool. 698) (1-0) Cr. 1. S.
Prerequisite: Permission of instructor. Bowen.
Concepts and research in cell biology.

699. RESEARCH.

CERAMIC ENGINEERING

David R. Wilder, Ph.D., Head of Department

The Graduate Faculty

Members: M.F. Berard, C.M. Dodd, O. Hunter, T.D. McGee, D.R. Wilder

Associate Members: J.T. Jones, E.A. Rosauer

The department offers work for the degrees Master of Science, Master of Engineering, and Doctor of Philosophy with major in ceramic engineering, and minor work to students taking major work in other departments.

Prerequisite to major graduate work is the completion of a curriculum in ceramic engineering, ceramic technology, engineering, or physical science equivalent to that required of undergraduate students at this institution.

There is no foreign language requirement for the degree Master of Science or Master of Engineering.

For the degree Doctor of Philosophy the foreign language requirement may be met in one of the following three ways: (1) A score of at least 400 in each of two Educational Testing Service foreign language examinations (French, German or Russian); (2) A score of at least 600 in one Educational Testing Service foreign language examination (French, German or Russian); (3) One year of formal course work (nine quarter hours) in either French, German, or Russian with a grade of at least C may be substituted for an Educational Testing Service score of 400; two years of formal course work (18 quarter hours) for an Educational Testing Service score of 600.

COURSES FOR GRADUATE STUDENTS, minor only

341. HIGH-TEMPERATURE PROCESSES.
(3-3) Cr. 4. F.
Prerequisite: 233.
Use of high-temperature treatment to effect atomic transport and densification through sintering and vitrification. Prediction of final fired structure by means of phase equilibrium diagrams.

342. VITREOUS STATE.
(3-3) Cr. 4. W.
Theory of vitreous state in ceramic glasses. Glass-forming reactions. Relationship of properties to composition and processing.

343. ELECTRONIC CERAMICS.
(3-0) Cr. 3. S.
Prerequisite: 221; credit or classification in E.E. 445 and Chem. 323.
Fundamentals of electronic processes in ceramic materials.

351. MICROSTRUCTURE OF CERAMIC MATERIALS.
(1-6) Cr. 3. F.
Prerequisite: 233.
Characterization of ceramic materials from information obtained by microscopy and X-ray analysis.

362. **COLLOID CHEMISTRY OF CERAMIC MATERIALS.**
(3-0) Cr. 3. W.
Prerequisites: 221, Chem. 321.
Fundamental phenomena associated with surfaces and colloidal systems of ceramic and related materials.

411. **CERAMIC INDUSTRIES I.**
(3-0) Cr. 3. F.
Prerequisite: 342.
Relationship of composition, crystal structure, fabrication techniques, and thermal processing to the properties of whitewares and technical ceramics.

412. **CERAMIC INDUSTRIES II.**
(3-0) Cr. 3. W.
Prerequisite: 351.
Manufacture, properties, uses, performance, and testing of basic, neutral, and acid refractories.

413. **CERAMIC INDUSTRIES III.**
(3-0) Cr. 3. S.
Prerequisite: 342.
Plant layout, processing, economic aspects, and structure of the enamel and glass industries. Inspection trip to porcelain enamel plant.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

512. **CERAMIC TECHNOLOGY.**
(3-0) Cr. 3. Offered as arr.
Prerequisite: Permission of instructor.
Physics and chemistry of inorganic glasses. Relationship of properties to composition and structure. Devitrified glasses. Melting, fining, and annealing.

513. **CERAMIC TECHNOLOGY.**
(3-0) Cr. 3. Offered as arr.
Prerequisite: 343 or permission of instructor.
Semiconducting, dielectric, and magnetic properties of ceramic materials and their interpretation with respect to composition and crystal structure.

514, 515. **ELECTRON MICROSCOPY OF INORGANIC MATERIALS.**
514: (2-6) Cr. 4: 515: (0-6) Cr. 3. Offered as arr.
Prerequisite: 514: Phys. 223; 515: 514.
Introduction to the theory of electron optics and image formation. Principles of electron microscope operation including various diffraction modes and X-ray microanalysis. Specimen preparation methods for inorganic materials.

516. **DEFECTS IN CRYSTALLINE CERAMICS.**
(3-0) Cr. 3. Offered as arr.
Prerequisite: Major in ceramic engineering.
Thermodynamics of point defects in ceramic crystals. Control of point defect concentration by stoichiometry, doping, and atmosphere.

521. **DIFFUSION IN CERAMIC SYSTEMS.**
(3-0) Cr. 3. Offered as arr.
Prerequisite: Permission of instructor.
Phenomenological and mechanistic approaches to diffusion in ionic solids. Diffusion measurements. Ionic conductivity.

532. **THEORY AND PROPERTIES OF COLLOIDAL AND RELATED CERAMIC MATERIALS.**
(3-3) Cr. 4. Offered as arr.
Prerequisite: Permission of instructor.
Fundamentals of colloidal phenomena as applied to ceramic systems, including theory of deflocculation, rheology, and measurements.

590. **SPECIAL TOPICS.**
Cr. arr.
Prerequisite: Permission of instructor.

COURSES FOR GRADUATE STUDENTS, major or minor

611. **MECHANICAL PROPERTIES OF CERAMIC MATERIALS.**
(3-0) Cr. 3. Offered as arr.
Prerequisite: 516.
Fundamentals of the elastic, anelastic, and plastic properties of ionic and covalent solids. Mechanical properties. Dislocations in ionic and covalent crystals.

612. **KINETICS OF CERAMIC PROCESSES.**
(3-0) Cr. 3. W.
Fundamentals of solid reactions occurring at elevated temperatures. Sintering, vitrification, diffusional mechanisms and effects, reaction rate theory.

613. **MEASUREMENTS IN HIGH TEMPERATURE SYSTEMS.**
(3-0) Cr. 3. S.
Theory, limitation, and problems of analysis of measurements at elevated temperatures. Furnaces and techniques for determination of mechanical, physical, structural, and chemical properties of ceramic materials at elevated temperatures.

618. **CRYSTAL CHEMISTRY OF CERAMIC MATERIALS.**
(3-0) Cr. 3. Offered as arr.
Fundamentals of crystal chemistry and the systematic study of the structures of the ceramic materials.

619. **PHASE EQUILIBRIA OF CERAMIC SYSTEMS.**
(3-0) Cr. 3. S.
Prerequisite: 618 or permission of instructor.
Phase equilibria of the ceramic and closely related systems.

699. **RESEARCH.**

CHEMICAL ENGINEERING

George Burnet, Jr., Ph.D., Head of Department

The Graduate Faculty

Members: W.H. Abraham, L.K. Arnold, R.G. Bautista, D.R. Boylan, L.E. Burkhart, G. Burnet, M.A. Larson, R.C. Seagrave, J.B. Sheeler, F.O. Shuck, F.D. Stevenson, G.T. Tsao, T.D. Wheelock

Associate Members: K.R. Jolls, A.H. Pulsifer, J.D. Stevens, D.L. Ulrichson

The department offers work for the degrees Master of Science, Master of Engineering, and Doctor of Philosophy with major in chemical engineering, and minor work to students taking major work in other departments.

Prerequisite to major graduate work is the completion of an undergraduate curriculum substantially equivalent to that offered in chemical engineering at this institution.

There is no foreign language requirement for the degrees Master of Science or Master of Engineering. For the degree Doctor of Philosophy a student must demonstrate a satisfactory reading knowledge of either French, German, Russian, or Spanish. For students whose native language is not English, the ability to communicate in English, certified by the Department of English, will, upon recommendation of the student's advisory committee, be acceptable as a substitute for the reading knowledge of one foreign language.

Minor work usually will be selected from chemistry, mechanical engineering, mathematics, physics, statistics, or nuclear engineering.

COURSES FOR GRADUATE STUDENTS, minor only

351. MULTISTAGE OPERATIONS.
(4-0) Cr. 4. F.
Prerequisite: 202.
Application of principles in 201 and 202 and physical chemistry to multistage processes for separation of chemical components. Equilibrium stage analysis of distillation, extraction, evaporation and crystallization. Problems involving design and operation of multistage process equipment are considered.

352. MOMENTUM TRANSPORT OPERATIONS.
(5-0) Cr. 5. W.
Prerequisite: 202, Math. 213, Phys. 221.
Concepts of momentum and mechanical energy transport in fluids are studied by examining problems related to fluid friction, viscosity, piping systems, settling, and flow through porous media. The subjects of filtration, sedimentation, and non-Newtonian fluids are also given attention.

353. ENERGY TRANSPORT OPERATIONS.
(3-0) Cr. 3. S.
Prerequisite: 352 or E.M. 378.
Consideration of thermal energy transfer problems which occur in the process industry. Principles developed in 352 are extended to conduction and convection of heat. Design of heat transfer equipment is a major topic. Radiant heat transfer is also covered.

435. PROCESS CONTROL.
(3-0) Cr. 3. F.
Prerequisite: 341, 353, Math. 321.
Mechanisms used to control industrial processes: their applications and limitations. Dynamics of chemical process components and process control systems. Analog simulation of process systems.

450. PROCESS CONTROL LABORATORY.
(0-4) Cr. 2. F.
Prerequisite: Credit or classification in 435.
Experiments in chemical process dynamics and control. Measurement of system parameters, transient response, and frequency response. Simulation of control systems. Transient response of chemical process equipment.

451, 452. CHEMICAL ENGINEERING LABORATORY.
(0-6) Cr. 2 each. W.S.
Prerequisite: Credit or classification in 454.
Measurement of transport properties and rates of heat, mass, and momentum transfer; investigation of process equipment, unit operations, and chemical reaction systems. Treatment of data, reports, and equipment design.

454. MASS TRANSPORT OPERATIONS.
(3-0) Cr. 3. F.
Prerequisite: 353.
The subjects of diffusion and mass transfer are studied in the context of chemical processes involving separation and synthesis. This course is an extension of 352 and 353. Problems of gas-liquid absorption, simultaneous heat and mass transfer, and chemical reactor technology are discussed.

461, 462. CHEMICAL ENGINEERING THERMODYNAMICS.
461: (3-0) Cr. 3. F; 462: (2-0) Cr. 2. W.
Prerequisites: 461: Math. 112, Phys. 222; 462: 461, and 341 or Com.S. 201.
Application of thermodynamic principles to chemical engineering problems. Thermodynamic properties of fluids, phase equilibria, chemical-reaction equilibra.

463. CHEMICAL REACTOR DESIGN.
(3-0) Cr. 3. S.
Prerequisite: 462.
Kinetics of chemical reactions, design of homogenous and catalytic flow and batch reactors.

471, 472, 473. CHEMICAL ENGINEERING DESIGN.
(1-6) Cr. 3 each. Yr.
Prerequisite: 471: Credit or classification in 454, 461; 472: 471, credit or classification in 462; 473: 472, credit or classification in 463.
Principles of process and plant design; economic and feasibility analysis; application of optimization techniques.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

500. INDIVIDUAL PROBLEMS.
Prerequisite: Major in chemical engineering.
Investigation of an approved topic on an individual basis.

515. ORGANIC CHEMICAL INDUSTRIES.
(3-0) Cr. 3. SS.
Prerequisite: Chem. 335.
Chemical engineering aspects of manufacture of the principal organic chemicals.

516. HEAVY INORGANIC CHEMICAL AND FERTILIZER INDUSTRIES.
(3-0) Cr. 3. SS.
Prerequisite: Permission of instructor.
Manufacture of commercial fertilizers and related heavy inorganic chemicals.

517. CHEMURGIC INDUSTRIES.
(3-0) Cr. 3. S.S.
Prerequisite: Chem. 335.
Occurrence, composition, and properties of agricultural products and their industrial treatment and utilization.
A. Carbohydrates and carbohydrate-bearing materials.
B. Vegetable and animal oils and fats.
C. Other products of agricultural origin.

520. BIOCHEMICAL ENGINEERING.
(3-0) Cr. 3. W.
Application of basic chemical engineering principles in biochemical and biological process industries such as fermentation, food processing, enzyme technology, and biological waste treatment.

535. PROCESS DYNAMICS.
(3-0) Cr. 3. S.
Prerequisite: 435.
Applications of dynamic analysis techniques in the study of nonsteady state chemical processes.

541, 542. CALCULATION METHODS FOR CHEMICAL ENGINEERS.
(3-0) Cr. 3 each. F.W.
Prerequisite: 541: 454, credit or classification in Math. 322; 542: 541.
541: Analysis and design of equipment and processes and the solution of the resulting differential equations by operational, series, and analog computer techniques. 542: Advanced analysis and design of equipment and processes by digital computer simulation and solution.

545. INDUSTRIAL CHEMICAL PROCESS MODELS.
(3-0) Cr. 3. SS.
Prerequisite: 542.
Construction and application of linear and nonlinear deterministic models for optimizing, planning, and scheduling chemical manufacturing processes. Introductory applications of stochastic models to chemical processes.

554, 555, 556. ADVANCED UNIT OPERATIONS.
(3-0) Cr. 3 each. Yr.
Prerequisite: 454.
554: Momentum transport processes in fluid-solid systems. Derivation and analysis of the basic equations of change; laminar and turbulent flow; flow through porous media and fluidization; flow past submerged bodies. 555: Energy transport processes. Steady-state and dynamic thermal processes, coupled energy and momentum transfer, and radiative transport. 556: Mass transfer. Diffusion theory, two-phase mass transfer, mass transfer efficiencies, coupled heat and mass transfer.

565. MULTI-STAGE OPERATIONS.
(3-0) Cr. 3. SS.
Prerequisite: 351.
General theory of multi-stage processes such as distillation, absorption, extraction, and ion exchange. Applications of finite difference calculus in cascade theory. Use of equilibrium phase relations and design optimization techniques.

566. SOLVENT EXTRACTION.
(3-0) Cr. 3. SS.
Prerequisite: 351.
Theory and application of solvent extraction to industrial processing.

581. THERMODYNAMICS OF SINGLE COMPONENT SYSTEMS.
(3-0) Cr. 3. F.
Prerequisite: 461.
Application of thermodynamic laws and fundamental relations to single component systems. Properties of nonideal fluids.

582. THERMODYNAMICS OF MULTI-COMPONENT SYSTEMS.
(3-0) Cr. 3. W.
Prerequisite: 581.
Thermodynamic properties of solutions. Phase equilibria and chemical reaction equilibria.

585. CHEMICAL ENGINEERING KINETICS.
(3-0) Cr. 3. S.
Prerequisite: 463.
Theory of absolute reaction rates; mass and heat transfer in catalytic beds; treatment of differential and integral conversion data.

590. SPECIAL TOPICS.
Cr. 2 to 5 each time taken.
A series of one-term courses chosen from such topics as catalytic reactor design, cost estimation, chemical engineering of nuclear processes, fluidized bed reactors, crystallization, polymerization, statistical thermodynamics, applied electro-chemistry, and bioengineering.

COURSES FOR GRADUATE STUDENTS, major or minor

601, 602, 603. SEMINAR.
(1-0) Cr. 1 each. Yr.

631, 632, 633. ADVANCED TRANSPORT PHENOMENA.
(3-0) Cr. 3 each. Alt. Yr, as arr.
Prerequisite: 556, Math. 322, 410.
Advanced topics in the transport of momentum, energy, and mass; derivation and application of equations of change; thermodynamics of irreversible processes; statistical theories of turbulence; eddy diffusion; boundary layer theory; particulate systems (packed and fluidized beds); non-Newtonian systems; correlation of transfer coefficients.

643. ADVANCED CALCULATION METHODS FOR CHEMICAL ENGINEERS.
(3-0) Cr. 3. S.
Prerequisite: 541.
Advanced analysis and design of equipment and processes requiring specialized mathematical techniques.

699. CHEMICAL ENGINEERING RESEARCH.

CHEMISTRY

John D. Corbett, Ph.D., Chairman of Department

The Graduate Faculty

Members: R.J. Angelici, O.L. Chapman, J.D. Corbett, H.C. Diehl, R.H. Edgar, J.H. Espenson, V.A. Fassel, H.F. Franzen, D. French, J.S. Fritz, B.C. Gerstein, H. Gilman, C.A. Goetz, R.S. Hansen, D.K. Hoffman, R.A. Jacobson, W.B. King, R.E. McCarley, D.S. Martin, J.E. Powell, K. Ruedenberg, G.A. Russell, F.H. Spedding, H.J. Svec, W.S. Trahanovsky, J.G. Verkade, A.F. Voight, W.C. Wildman, H.A. Wilhelm

Associate Members: T.J. Barton, G.V. Calder, J.C. Clardy, W. Hutton, Jr., D.C. Johnson, C.J.V. Scanio, G.J. Small

The department offers work for the degrees Master of Science and Doctor of Philosophy with majors in analytical, inorganic, organic, and physical chemistry and in combinations thereof. Minor work is offered to students taking major work in other departments.

In cooperation with the Institute for Atomic Research, special facilities are offered to graduate students in other departments of the University who wish to use radioactive isotopes in their research. Analytical chemistry, calculus, and physics are required for this phase of chemistry.

The Department of Chemistry requires all graduate students majoring in chemistry to teach as part of their training for an advanced degree.

Prerequisite to major graduate work is the completion of undergraduate work in chemistry, mathematics, and physics, substantially equivalent to that required of undergraduate students at this institution in the curriculum in chemistry.

COURSES FOR GRADUATE STUDENTS, minor only

301, 302. INORGANIC CHEMISTRY.
(3-0) Cr. 3 each. 301: W; 302: S.
Prerequisite: 325 or 322.
Bonding in inorganic systems; descriptive and systematic chemistry of the elements. Emphasis on correlation of structure and bonding with chemical and physical properties of inorganic compounds; applications of thermodynamics, kinetics, and other physical methods to study of inorganic systems.

321, 322, 323. PHYSICAL CHEMISTRY.
(3-0) Cr. 3 each. 321: F.S; 322: F.W; 323: W.S.
Prerequisite: 321: 211 or 142, Phys. 223, Math. 112 recommended; 322: 321; 323: 322.
Properties of gases, liquids, and solids; solutions; thermochemistry and thermodynamics; chemical kinetics; electrochemistry; atomic and molecular structure. Students majoring in chemistry or biochemistry ordinarily will elect 224, 325, 326, 327.

322L. LABORATORY IN PHYSICAL CHEMISTRY.
(0-3) Cr. 1. W.
Prerequisite: Credit or classification in 322 recommended.
Should accompany 322.

323L. LABORATORY IN PHYSICAL CHEMISTRY.
(0-6) Cr. 3. S.
Prerequisite: 322L, credit or classification in 323 recommended.
Should accompany or follow 323.

334, 335, 336. ORGANIC CHEMISTRY.
(3-0) Cr. 3 each. 334: F.W; 335: W.S; 336: S.
Prerequisite: 142 and 142L, or 148 and 148L.
Modern organic chemistry, including nomenclature, synthesis, structure and bonding, reaction mechanisms, physical methods, carbohydrates, proteins, and lipids. Premedical students will take this sequence. Students majoring in chemistry will ordinarily take 331, 332, 333.

408. RADIOCHEMISTRY.
(2-6) Cr. 4. F.
Radioactivity; theory, operation and uses of radiation measuring instruments; principles of radiochemistry. For students in engineering.

426. RADIOTRACER METHODS.
(2-0) Cr. 2. F.
Prerequisite: 323 or 326 or 493; Phys. 112.
Radioisotope techniques and their applications to problems in biology and allied sciences. For students in biology and agriculture.

493, 494. BIOPHYSICAL CHEMISTRY.
(3-0) Cr. 3 each. 493: F; 494: W.
Prerequisite: Math. 112.
Physical chemistry with application to biological systems. Not accepted for credit toward a degree in chemistry or chemical engineering. 322L and 323L may be taken concurrently by those desiring laboratory.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

501. **INORGANIC PREPARATIONS.**
(0-6) Cr. 2. F.
Prerequisite: 302.
Preparation and characterization of inorganic and organometallic compounds by modern research techniques.

505. **PHYSICAL PRINCIPLES OF INORGANIC CHEMISTRY.**
(3-0) Cr. 3. F.S.
Prerequisite: 302 and 323 or 326.
Theoretical concepts of bonding and structure applied to inorganic chemistry. Elementary group theory, hybridization and localized covalent bonding, molecular orbitals, and ligand field theory.

506. **APPLICATION OF PHYSICAL METHODS IN INORGANIC CHEMISTRY.**
(3-0) Cr. 3. W.
Prerequisite: 505.
Spectrometric, magnetic, and diffraction measurements in inorganic and organometallic research problems. Emphasis on stereochemical and bonding information.

507. **SYSTEMATIC INORGANIC CHEMISTRY.**
(3-0) Cr. 3. S.
Prerequisite: 505, and 506 or 536 or 592.
Descriptive chemistry of the metallic and nonmetallic elements.

511. **ADVANCED QUANTITATIVE ANALYSIS.**
(3-0) Cr. 3. S.
Prerequisite: 316, and 323 or 326, and 333 or 336.
General methods, descriptive inorganic analysis, and current literature.

512. **ELECTROCHEMICAL METHODS OF ANALYSIS.**
(2-3) Cr. 3. F.
Prerequisite: 316, and 323 or 326, and 333 or 336.
Principles and applications of electrochemical methods and mass spectrometry.

513. **MOLECULAR ABSORPTION SPECTROPHOTOMETRY.**
(2-3) Cr. 3. W.
Prerequisite: 316, and 323 or 326, and 333 or 336.
Principles and analytical applications of absorption spectrophotometry.

514. **ANALYTICAL ATOMIC SPECTROSCOPY.**
(2-0) Cr. 2. S.
Prerequisite: 323 or 326; Phys. 223.
Principles and experimental methods of optical emission spectroscopy, atomic absorption spectroscopy, and X-ray fluorescence spectroscopy.

515. **ANALYTICAL ATOMIC SPECTROSCOPY LABORATORY.**
(0-6) Cr. 2. F.W.S.
Prerequisite: 514.
Laboratory in optical emission, atomic absorption, and X-ray fluorescence spectroscopy.

516. **QUANTITATIVE ORGANIC ANALYSIS.**
(1-3 to 9) Cr. 2 to 4. W.
Prerequisite: 333 or 336.
Chemical analysis via functional groups, kinetic methods, spectrophotometric and physical methods, analytical separations. Optional laboratory work on a special analytical problem.

517. **SPECIAL PROBLEMS IN ANALYTICAL CHEMISTRY.**
(0-3 to 12) Cr. 1 to 4.
Prerequisite: Permission of instructor.
Laboratory work on a special project in chemical analysis.

521. **STATISTICAL THERMODYNAMICS.**
(3-0) Cr. 3. F.
Prerequisite: 323 or 326.
Boltzman distribution, thermodynamics from a statistical viewpoint, Einstein and Debye crystals, ideal gases, equipartition theorem, kinetic theory, review of kinetics.

522. **CHEMICAL THERMODYNAMICS I.**
(3-0) Cr. 3. W.
Prerequisite: 323 or 326.
Gases, solutions, homogeneous and heterogeneous equilibria.

523. **CHEMICAL THERMODYNAMICS II.**
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: 522.
Applications to chemical systems.

524. **SURFACE CHEMISTRY.**
(3-0) Cr. 3. Alt. W, offered 1973.
Prerequisite: 323 or 326.
Basic principles and applications.

526, 527. **RADIOCHEMISTRY.**
(2-0) Cr. 2 each. 526: Alt. W, offered 1972; 527: Alt. S, offered 1972.
Prerequisite: 323 or 326.
Natural and artificial radioactivity; sources, preparations, and properties. Measurement of radiations. Chemistry of the radio-elements. Applications of radioactive isotopes.

528. **CHEMICAL KINETICS AND MECHANISMS.**
(3-0) Cr. 3. S.
Prerequisite: 323 or 326.
Methods of studying reaction rates and mechanisms; inference of mechanisms from rate laws; reversible, consecutive, and competing reactions; chain mechanisms; exchange reactions; isotope rate effects; very rapid reactions; acid-base catalysis; theories of unimolecular reactions; absolute rate theory.

529. **LABORATORY IN RADIOTRACER TECHNIQUES.**
(0-6) Cr. 2. W.S.
Prerequisite: 426.
Measuring and handling radioactive substances in chemical and biological experiments.

531, 532. **MECHANISTIC THEORY OF ORGANIC CHEMISTRY.**
(3-0) Cr. 3 each. 531: W; 532: S.
Prerequisite: 323 or 326; 333 or 336.
Organic reaction mechanisms, organic synthesis, stereochemistry of organic processes.

535. **ADVANCED ORGANIC LABORATORY.**
(0-3 or more) Cr. 1 or more each time taken. F.W.S.SS.
Prerequisite: Permission of staff member with whom work is to be done.
Experimental techniques in organic chemistry.

536. **INTRODUCTION TO ORGANIC CHEMISTRY RESEARCH.**
(2-3) Cr. 3. F.
Prerequisite: 323 or 326, and 333 or 336.
Principles of infrared, ultraviolet, nuclear magnetic resonance, and electron spin resonance spectroscopy as applied to organic chemistry. Physical methods of purification, separation, and characterization of organic materials.

539. **ADVANCED ORGANIC CHEMISTRY.**
(3-0) Cr. 3. F.SS.
Prerequisite: 323 or 326, and 333 or 336.
Descriptive organic chemistry with emphasis on synthesis and stereochemistry.

590. **SPECIAL TOPICS IN PHYSICAL CHEMISTRY.**
(1-0) Cr. 1.
Introduction to the various areas of current research in physical chemistry at Iowa State University.

591. **SYMMETRY AND MOLECULAR STRUCTURE.**
(2-0) Cr. 2. S.
Prerequisite: 323 or 326.
Molecular symmetry elements, symmetry adapted wave functions, applications to the electronic structure of molecules and spectroscopy.

592. **CHEMICAL BONDING AND STRUCTURE.**
(3-0) Cr. 3. S.
Prerequisite: 505, or Phys. 548 and classification in 591.
Variation principle of quantum mechanics, atomic orbitals, many electron systems, atomic states and angular momentum, atoms in crystal fields, diatomic molecules, polyatomic molecules, complexes, electron deficient molecules, pi-electron systems, hydrogen bonds, vanderWaals bonds, metallic bonds.

593. **CHEMICAL SPECTROSCOPY AND STRUCTURE.**
(3-0) Cr. 3. F.
Prerequisite: 505 or 591.
Interaction of radiation and matter; radio frequency, infrared, visible and ultraviolet spectroscopy.

594. **DIFFRACTION AND MOLECULAR STRUCTURE.**
(2-0) Cr. 2. F.
Prerequisite: Permission of instructor.
X-ray, neutron and electron diffraction: scattering by electrons, atoms, and molecules. Translation and point group symmetry, application of Fourier methods. Examples of structures deduced from diffraction techniques.

COURSES FOR GRADUATE STUDENTS, major or minor

600. **SEMINAR IN INORGANIC CHEMISTRY.**
(1-0) Cr. 1 each time taken. F.W.S.
Prerequisite: Permission of instructor.

601. **SELECTED TOPICS IN INORGANIC CHEMISTRY.**
(2 or 3-0) Cr. 2 or 3 each time taken. F.W.S.
Prerequisite: 302 or equivalent.
Topics such as chemical applications of group theory, molecular structure and bonding, organometallic compounds, physical techniques of structure determination, nonaqueous solvents, reaction mechanisms, and ligand field theory.

611. **SEMINAR IN ANALYTICAL CHEMISTRY.**
(1-0) Cr. 1 each time taken. F.W.S.
Prerequisite: Permission of instructor.

620. **SEMINAR IN PHYSICAL CHEMISTRY.**
(1-0) Cr. 1 each time taken. W.S.
Prerequisite: Permission of instructor.

621. **STATISTICAL MECHANICS.**
(3-0) Cr. 3 each time taken. Alt. W.S, offered 1972.
Prerequisite: Permission of instructor.
Review of classical and quantum mechanics, principles of statistical mechanics, applications to thermodynamics and other related problems.

622. **QUANTUM CHEMISTRY.**
(3-0) Cr. 3 each time taken. Alt. W.S, offered 1973.
Prerequisite: Permission of instructor.
The Schroedinger equation, solution in simple cases, perturbation, and variation methods. Slater's treatment of complex atoms and molecules, valence bond, and molecular orbital methods; applications.

625. **SELECTED TOPICS IN PHYSICAL CHEMISTRY.**
(0-2) Cr. 2 each time taken. F.W.S.
Prerequisite: 521 or 592.
Topics such as atomic, molecular, and nuclear structure; surface chemistry; photochemistry; chemical kinetics; electrochemistry; phase rule.

626. **CRYSTAL STRUCTURE ANALYSIS.**
(2-0) Cr. 2 each time taken. W.S. Must be started in winter.
Prerequisite: Permission of instructor.
X-ray and neutron diffraction as applied to the solid state, kinematic theory of diffraction, space group symmetry, applications of Fourier and least-squares methods, methods for phasing structural amplitudes, examples of structures deduced from X-ray and neutron studies.

631. **SEMINAR IN ORGANIC CHEMISTRY.**
(1-0) Cr. 1 each time taken. F.W.S.SS.
Prerequisite: Permission of instructor.

632. **SELECTED TOPICS IN ORGANIC CHEMISTRY.**
(2-0) Cr. 2 each time taken. F.W.S.SS.
Prerequisite: 532.
Topics of current interest in organic chemistry such as electron spin resonance spectroscopy, nuclear magnetic resonance spectroscopy, mass spectroscopy, physical organic chemistry, photochemistry, natural products, organometallic chemistry, computer techniques, modern synthetic methods, mechanisms of reductions and oxidations, carbenes, molecular orbital theory, heterocycles, free radicals, and kinetics.

699. **RESEARCH.**
Prerequisite: Permission of staff member concerned.

CHILD DEVELOPMENT

The Graduate Faculty

Member: D. Pease

Associate Member: S.G. Clark

The department offers work for the degrees Master of Science and Doctor of Philosophy with major in child development, and minor work for students taking major work in other departments.

In addition to fulfilling graduate college admission requirements, the students should have a substantial background in one of the following fields: child development, family relations, human biology, human nutrition, education, anthropology, psychology, sociology.

As a supplement to course work in major and minor fields, candidates for the degree Master of Science must exhibit proficiency in a relevant skill. To meet this proficiency requirement and with his advisory committee's approval, the student may elect one of the following alternatives: (1) reading knowledge of French, German, or Russian; (2) satisfactory completion of a two-quarter sequence in statistical methods, Educ. 552 and 553 or Stat. 401 and 402; (3) satisfactory completion of one course in psychological measurements.

Candidates for the degree Doctor of Philosophy must demonstrate a satisfactory reading knowledge of one language to be selected from French, German, or Russian.

COURSES FOR GRADUATE STUDENTS, minor only

460. **GUIDANCE OF CHILDREN.**
(3-2) Cr. 4. F,W,S,SSI.
Prerequisite: 366 or El.Ed. 344.
Principles of guidance applied to children in group situations. Observation of and participation in adult-child interaction.

461. **PLANNING CURRICULA FOR THE YOUNG CHILD.**
(2-0) Cr. 2. F,W,S.
Prerequisite: 460.
Principles and techniques of planning curricula for groups of young children.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

500. **SHORT COURSE.**
Cr. 1 to 3. SS.
Prerequisite: Permission of instructor.
Concentrated group study of various educational problems in the field of child development.

519. **SELECTED RESEARCH METHODS IN CHILD DEVELOPMENT.**
(3-0) Cr. 3. F.
Prerequisite: Credit or classification in Stat. 401 or Educ. 552.
Identification of research areas. Use of observation, interview, questionnaire, sociometric and rating techniques in child development research; preparation of instruments and methods of data analysis, interpretation, and dissemination of data.

520. **RESEARCH DESIGN IN CHILD DEVELOPMENT.**
(3-0) Cr. 3. Alt. W, offered 1973.
Prerequisite: 519.
Methods of experimental research with children; research designs in child development.

536. **PRINCIPLES OF GROWTH AND DEVELOPMENT.**
(3-0) Cr. 3. F.
Prerequisite: 336, 337.
Analysis of the developmental approach to the study of child behavior. Emphasis upon principles of development. Laboratory observation.

537. **THEORIES OF CHILD DEVELOPMENT.**
(3-0) Cr. 3. W.
Prerequisite: 536.
Theoretical foundations of child development. Examination of major theories and the supporting research evidence.

538. **INFANT GROWTH AND BEHAVIOR.**
(2-2) Cr. 3. S.
Prerequisite: 536, Zool. 358.
Advanced study of infant behavior and development; current research with infants.

540. **THE CHILD WITH LEARNING DISABILITIES.**
(3-0) Cr. 3. F,SSI.
Prerequisite: Nine credits in child development, Psych. 333.
Neurological bases and developmental preconditions of learning. Physiological and experimental inferences to learning; symptomatology; diagnostic procedures.

541. **THE GIFTED CHILD.**
(3-0) Cr. 3. W,SSI or SSII.
Prerequisite: Twelve credits in behavioral sciences, including Psych. 333.
Characteristics of children with superior abilities. Major emphasis placed on intellectual styles of operations, creativity, and strategies for enhancing development of talent.

542. **THE DISADVANTAGED CHILD.**
(3-0) Cr. 3. S,SSI or SSII.
Prerequisite: Three credits in educational psychology.
Identification and analysis of problems. Implications for the educative process.

572. **PARENT EDUCATION.**
(3-0) Cr. 3. F.
Prerequisite: Three credits in child development, three credits in family relationships.
Principles and procedures of instruction and evaluation in parent education.

581. **PROGRAMMING FOR YOUNG CHILDREN.**
Cr. arr. W.
Prerequisite: Twelve credits in child development. Reservation required.
Planning educational group experiences for young children and their families. Study of programs for normal and exceptional preschool children.

590. **SPECIAL TOPICS.**
Cr. 1 to 4 each time elected.
Prerequisite: Twelve credits in child development, permission of department head.
A. Child Development.
B. Nursery Education.
C. Community Services.

COURSES FOR GRADUATE STUDENTS, major or minor

600. **HISTORY AND PHILOSOPHY OF CHILD DEVELOPMENT.**
(3-0) Cr. 3. W.SSI.
Prerequisite: Six credits in child development.
History of child development; research centers; theories of early childhood education.

601. **THEORIES IN THE EDUCATION OF YOUNG CHILDREN.**
(2-3) Cr. 3. S.
Prerequisite: 460.
Theories, objectives, and recent research used in nursery education; role of nursery education in the total educational system; observation of a variety of programs for young children.

620. **DEVELOPMENTAL APPRAISAL OF THE CHILD.**
(3-0) Cr. 3. S.
Prerequisite: Psych. 440.
Analysis of methods in the clinical and experimental appraisal of children.

630. **DEVELOPMENTAL PROCESSES IN CHILDREN: PHYSICAL AND MOTOR.**
(2-0) Cr. 2. Alt. S, offered 1972.
Prerequisite: 536, 537.
Theories and concepts of growth, maturation, and motor coordination as related to personal and social development.

631. **DEVELOPMENTAL PROCESSES IN CHILDREN: COGNITION.**
(4-0) Cr. 4. Alt. W, offered 1973.
Prerequisite: 536, 537.
Analysis of cognitive development in children.

632. **DEVELOPMENTAL PROCESSES IN CHILDREN: PERSONALITY.**
(4-0) Cr. 4. Alt. W, offered 1972.
Prerequisite: 536, 537.
Analysis of personality formation in children.

633. **DEVELOPMENTAL PROCESSES IN CHILDREN: SOCIAL.**
(2-0) Cr. 2. Alt. S, offered 1971.
Prerequisite: 536, 537.
Analysis of social development in children.

655. **PLANNING COLLEGE COURSES IN CHILD DEVELOPMENT.**
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: 600.
Selection, organization, and presentation of subject matter.

665. **SEMINAR.**
Cr. arr. F.W.S.

670. **DYNAMICS OF PARENT-CHILD RELATIONSHIPS.**
(2-0) Cr. 2. S.
Prerequisite: Fifteen credits in child development and psychology.
Analysis of theories applicable to the dynamics of parent-child interactions.

671. **CROSS-CULTURAL STUDIES OF CHILD REARING PRACTICES.**
(3-0) Cr. 3. Alt. F, offered 1972.
Prerequisite: Anthro. 422, permission of instructor.
An examination of current research on the child in a cross-cultural perspective.

699. **RESEARCH.**

CIVIL ENGINEERING

Carl E. Ekberg, Jr., Ph.D., Head of Department

The Graduate Faculty

Members: E.R. Baumann, R.A. Caughey, J.L. Cleasby, L.H. Csanyi, T. Demirel, C.E. Ekberg, Jr., R.L. Handy, P.E. Morgan, C.S. Oulman, W.W. Sanders, H.F. Seidel, J.B. Sheeler, M.G. Spangler, R.E. Untrauer

Associate Members: K.A. Brewer, R.L. Carstens, M.D. Dougal, H.A. Elleby, H.P. Fung, R.L. Hardy, J.M. Hoover, W.T. Hosmer, T.C. Jellinger, S. Kelman, F.W. Klaiber, D.Y. Lee, T.T. Lee, R.A. Lohnes, J.L. Mickle, J.C. Young

The department offers work for the degrees Master of Science and Master of Engineering with majors in civil, highway, municipal, sanitary, soil, structural, and transportation engineering; for the degree Doctor of Philosophy with majors in transportation, structural, soil, and sanitary engineering; and minor work to students taking major work in other departments. Within the civil engineering major, the student may specialize in geodesy and photogrammetry.

There is no foreign language requirement for the degrees Master of Science or Master of Engineering. The department strongly recommends that all candidates for the degree Doctor of Philosophy demonstrate a significant level of proficiency in one of the following languages: French, German, Russian, or Spanish. However, with the approval of a doctoral candidate's program of study committee, 9 additional credits of course work outside the Department of Civil Engineering may be substituted for a language requirement.

Prerequisite to major graduate work is the completion of a curriculum substantially equivalent to that required of undergraduate students in civil engineering at this institution, and including undergraduate courses necessary for the particular field chosen.

Students who major in civil engineering usually will select minor work from the departments of Mathematics, Physics, Chemistry, Bacteriology, Geology, Economics, Statistics, or other engineering departments.

COURSES FOR GRADUATE STUDENTS, minor only

304. HYDROLOGY.
(2-3) Cr. 3. W.S.SS.
Prerequisite: Com.S. 201, Stat. 105.
Elements of hydrology, precipitation, water losses, stream flow and ground water hydraulics.

331. ANALYSIS OF STATICALLY DETERMINATE STRUCTURES.
(3-0) Cr. 3. F.W.
Prerequisite: E.M. 324, or classification in E.M. 326.
Reactions, shears, moments, and deflected shapes in beams and frames, stresses in trusses for dead and live loads. Approximate methods for high-rise building frames. Influence lines, loading criteria, Betti's law, Mueller-Breslau principle. Deflections by moment area.

350. COLLABORATIVE TRANSPORTATION DEVELOPMENT.
(3-0) Cr. 3. F.S.
History, legal requirements, organizations, and coordination in national, state, and local development of transport modes. The planning, regulation, safety, operation, and circulation patterns of air, rail, water, pipeline, street, and road systems. Population, land use, economic, social, and other source data for use in the location of transportation routes, parking, and terminal facilities.

352. PLANNING OF TRANSPORTATION FACILITIES.
(3-0) Cr. 3. W.S.SS.
Prerequisite: Credit or classification in 213 and Stat. 105.
Introduction to planning for systems of highway, rail, air, water, and pipeline transportation. Selection of route and mode based on economic and financial factors, technological characteristics, and other factors. Transportation terminals.

360. SOIL ENGINEERING.
(3-0) Cr. 3. F.SS.
Prerequisite: Geol. 301, credit or classification in E.M. 324.
Introduction to basic soil engineering; soil structure, soil mineralogy, soil water systems, and interactive forces; principles of settlement and shearing stresses in soils; application of soil engineering in embankments, retaining walls, foundations, piles and underground conduits.

361. SOIL AND AGGREGATE MATERIALS LABORATORY.
(0-6) Cr. 3. W.
Prerequisite: Geol. 301, credit or classification in E.M. 324.
Introduction to soil and aggregate materials testing. Identification and classification tests of engineering soils and aggregates. Physical and chemical properties tests of soil-granular systems.

362. DESIGN OF CONCRETES AND STABILIZED SOIL SYSTEMS.
(0-6) Cr. 3. S.
Prerequisite: 361, E.M. 354.
Physical and chemical properties of bituminous, portland, and other cements. Design and testing of concretes and stabilized soil systems. Admixtures. Mixing, handling, placing, and curing.

394, 395. PROFESSIONAL DEVELOPMENT.
Cr. R; 394: F; 395: W.
Oral reports and discussions of prominent engineers, notable engineering projects and related topics.

404. ENGINEERING IN CITY PLANNING.
(3-0) Cr. 3. W.
Prerequisite: 350, Ur.Pl. 270 or C.E. 426 and 453.
Relation of sanitary works, transportation, and other utilities to city planning; housing, building codes, real estate subdivision, land titles.

415. GEODETIC SURVEYING.
(2-3) Cr. 3. F.
Prerequisite: 213 or 214 or Geol. 302.
Geodetic control surveys. Precise triangulation, trilateration, traversing, and leveling. Geodetic computation on the ellipsoid. Design of geodetic surveys for various applications. Introduction to adjustment theory.

416. PRINCIPLES OF GEODESY.
(3-0) Cr. 3. S.
Prerequisite: 213 or 214 or Geol. 302.
General theory of geometric and physical geodesy. Application of geodetic surveys, including gravity, to scientific problems. Size and shape of the earth. Introductory theory of the geoid. Isostasy.

417A, 417B. LAND SURVEYING.
417A: (1-6); 417B: (3-0) Cr. 3 each. S.
Prerequisite: 417A: 213; 417B: Credit or classification in 417A.
417A: Methods used in original public land surveys. Boundary retracement. Subdivision layout. 417B: Legal aspects. Case studies in litigation involving surveys. Deed descriptions and recording. Zoning, subdivision, and real estate law.

418. PHOTOGRAMMETRY I.
(2-3) Cr. 3. W.
Prerequisite: 212 or 214 or Geol. 204.
General photointerpretation. Principles of optics and photography. Cameras and camera calibration. Geometry of photographs. Flight planning. Mosaics and photomaps. Stereoscopy and parallax. Theory of and practice with analogue instrumentation.

425. SANITARY ENGINEERING I.
(2-3) Cr. 3. F.W.
Prerequisite: Chem. 142, Math. 213, Phys. 221.
Introduction to those studies in which engineering knowledge is applied to problems concerning public health, including water and waste water treatment, the prevention and control of air pollution, stream pollution, and communicable diseases.

426. SANITARY ENGINEERING II.
(2-6) Cr. 4. F.W.
Prerequisite: 304, 425, E.M. 378.
Engineering aspects of collection, pumping, storage, and distribution of water for public, domestic and industrial uses; and collection of storm, sanitary, and combined waste water. Design of systems.

427. SANITARY ENGINEERING III.
(2-3) Cr. 3. S.
Prerequisite: 426.
Extension of principles presented in 425 and 426 and application to integrated water supply or pollution-control design problems.

428. SANITARY ENGINEERING IN PUBLIC HEALTH.
(3-0) Cr. 3. W.
Prerequisite: 425.
The sanitary engineer's responsibility in public health and hygiene. Organization, administration, and operation of public health agencies.

432. ANALYSIS OF STATICALLY INDETERMINATE STRUCTURES.
(4-0) Cr. 4. W.S.
Prerequisite: 331, Com.S. 201.
Analysis of continuous beams and frames by consistent deformations, slope deflection, moment distribution. Truss analysis by virtual work. Application of loading criteria.

433. **STRUCTURAL STEEL DESIGN.**
(3-0) Cr. 3. F.S.
Prerequisite: 432, Math. 213, E.M. 327, 354.
Design and behavior of the elements of steel structures, proportioning of members and connections, introduction to plastic design.

434. **REINFORCED CONCRETE DESIGN.**
(3-0) Cr. 3. F.W.
Prerequisite: 432, Math. 213, E.M. 327, 354.
Design and behavior of elements of reinforced concrete structures such as beams, columns, footings, and slabs.

448. **ADVANCED STEEL STRUCTURES.**
(3-0) Cr. 3. W.
Prerequisite: 433, credit or classification in Math. 321.
Plastic design; built-up beams and girders: composite design; metal folded plates and domes; design considerations for fatigue, bracing, and connections; structural systems.

449. **ADVANCED REINFORCED CONCRETE STRUCTURES.**
(3-0) Cr. 3. S.
Prerequisite: 434, credit or classification in Math. 321.
One-way slab, beam, and girder floors; two-way and flat slabs; building frames; footings; retaining walls; introduction to prestressed concrete.

450. **TRAFFIC ENGINEERING.**
(3-3) Cr. 4. W.
Prerequisite: 352.
Elements of highway and street traffic circulation and planning. Driver and vehicle performance. Traffic analysis and traffic control. Parking. Lighting. Safety.

451. **TRAFFIC PLANNING.**
(3-2) Cr. 4. S.
Prerequisite: 350 or 450.
Planning of highway systems and terminals considered as a part of the complete planning approach; traffic studies, projections, analysis, plan formulation, and programming.

453. **DESIGN OF TRANSPORTATION FACILITIES.**
(3-3) Cr. 4. F.S.
Prerequisite: 304, 352, 362, E.M. 378.
Location and safe geometric design of highway facilities. Earthwork and drainage related to highway, railway and airport design. Design, construction, and maintenance of pavements and stabilized bases.

460. **FOUNDATIONS.**
(3-0) Cr. 3. S.
Prerequisite: 360.
Fundamentals of foundation engineering. Exploration and site evaluation. Determination of allowable bearing capacity of soils. Selection and design of foundation on sand, silt, clay, and nonuniform soils.

472. **APPLIED HYDRAULIC DESIGN.**
(2-2) Cr. 3. S.
Prerequisite: 304, E.M. 378.
Characteristics of flow in natural and artificial channels; hydraulic design of culverts, bridge waterway openings, spillways, stilling basins, hydraulic gates and gated structures, miscellaneous water control structures.

485. **ENGINEERING CONSTRUCTION.**
(2-2) Cr. 3. F.W.S.
Prerequisite: Credit or classification in E.M. 354.
Quantity surveys, cost keeping, letting procedures and contract documents, form design, construction methods, and equipment. Relations between contractor, owner, and engineer.

486. **CIVIL ENGINEERING SPECIFICATIONS.**
(3-0) Cr. 3. S.
Prerequisite: Stat. 105, credit or classification in I.Ad. 365A or I.E. 480.
The preparation of specifications for structures, highway, and public works development.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

505. **PUBLIC WORKS ENGINEERING.**
(3-0) Cr. 3. S.
Prerequisite: 427.
Job classification and specification; construction contracts and specifications; unit costs; special assessments; building codes; fire protection; refuse collection and disposal; street and work maintenance; subdivision design and layout.

510. **PHOTOGRAMMETRY II.**
(2-3) Cr. 3. Alt. F, offered 1971.
Prerequisite: 418 or For. 445.
Advanced theory of, and practice with Multiplex and Kelsh-type plotters. Theory of higher order plotters. Advanced parallax theory; model deformations. Accuracies of relative orientation and elevation determinations.

511. **SURVEYING USING ELECTRONIC INSTRUMENTS.**
(2-3) Cr. 3. Alt. S, offered 1973.
Prerequisite: 415, Phys. 223.
Fundamentals of electronic surveying with the geodimeter, tellurometer, hiran and similar electronic systems. Geometric design of system layouts involving hyperbolic positioning, airborne line-crossing, and satellite methods. Theory and practice in electronic trilateration.

512. **GEODETIC ASTRONOMY.**
(2-3) Cr. 3. Alt. S, offered 1973.
Prerequisite: 415, Math. 112.
Celestial sphere and terrestrial coordinate systems. Coordinate transformations. Theory of precise determinations of latitude, longitude, azimuth, and time. Astronomical and instrumental corrections. Practice in observation and computation.

513. **ADJUSTMENT OF OBSERVATIONS.**
(2-3) Cr. 3. Alt. W, offered 1973.
Prerequisite: 416, 418, Stat. 105.
Theory of errors. Error propagation in geodetic and photogrammetric systems. Observation and condition equations. Practice in the application of theory of least squares to adjustment of observations. Error analyses.

515. **ADVANCED GEOMETRIC GEODESY.**
(3-0) Cr. 3. Alt. F, offered 1971.
Prerequisite: 416.
Geometrical geodesy applied to super-long distance measurements. Adjustment of electronic survey nets. Figure of the earth by advanced geometric methods. Three-dimensional world geodetic system.

516. ANALYTICAL PHOTOGRAMMETRY.
(2-3) Cr. 3. Alt. S, offered 1972.
Prerequisite: 510, Math. 307.
Fundamental concepts, principles, and methods of analytical photogrammetry. Collinearity, coplanarity, and scale restraints. First order stereoplotting instruments and comparators. Relative and absolute orientation. Adjustment of strips and blocks. Coordinate transformation.

518. PHYSICAL GEODESY.
(3-0) Cr. 3. Alt. W, offered 1972.
Prerequisite: 416, Math. 321; classification in E.M. 548 or Phys. 355.
Gravity and potential theory. Geoid and equipotential surfaces. Computation of geoidal undulations and deflections of the vertical. Isostatic theory. Gravity meter and torsion balance observations. Gravity data reduction. Spherical harmonic analysis.

520. WATER AND WASTE WATER ANALYSIS.
(0-9) Cr. 3 to 6. W.
Prerequisite: 425, and Chem. 211 or 114.
Review of the principles of gravimetric, volumetric, and colorimetric methods of analysis. Application of these principles to the laboratory analysis of water and waste water samples.

522. WATER POLLUTION CONTROL PLANT DESIGN.
(2-3) Cr. 3. S.
Prerequisite: Biol. 101, credit or classification in 427.
Investigation and planning activities used to evaluate need for water pollution control facilities and design of such facilities.

523. WATER TREATMENT PLANT DESIGN.
(2-3) Cr. 3. W.
Prerequisite: 426, credit or classification in Chem. 211.
Investigation and planning activities used to evaluate adequacy of existing municipal water supply and treatment facilities. Design of municipal water treatment facilities.

525. PHYSICAL-CHEMICAL TREATMENT PROCESSES.
(2-3) Cr. 3. S.
Prerequisite: 425, and Chem. 114 or 211.
Principles of important processes in water and waste treatment. Applications of these principles to solve specific treatment problems. Studies in adsorption, ion exchange, reverse osmosis, and electrodialysis.

528. FUNDAMENTALS OF BIOLOGICAL WASTE TREATMENT.
(2-3) Cr. 3. F.
Prerequisite: 520, Chem. 334, Bact. 300.
Relationship of the fundamentals of biological growth to the design and operation of biological waste-treatment systems. Characterization of wastes relative to their treatability and the selection of appropriate processes for their treatment.

529. LOW-LEVEL RADIOACTIVE WASTES.
(3-0 to 9) Cr. 3 to 6. S.
Prerequisite: Nuc.E. 510 or Chem. 408.
Sources of radioactive wastes. Principles of handling, treating, and disposing of low-level wastes which arise from nuclear energy operations.

532. STRUCTURAL ANALYSIS BY NUMERICAL PROCEDURES.
(3-0) Cr. 3. W.
Prerequisite: 433, Math. 321, E.M. 345.
Analysis of structural problems by methods of successive approximations and numerical procedures; moments and deflections of beams, influence lines, moments and deflections of beams under combined axial and bending loads, buckling strength of columns and frames, beams on elastic foundations.

533. STRUCTURAL ANALYSIS BY MATRIX METHODS.
(3-0) Cr. 3. S.
Prerequisite: 432, Math. 321.
Analysis of structural problems by means of matrix formulation; flexibility method of analysis, stiffness method of analysis.

534. ADVANCED STRUCTURAL ANALYSIS.
(3-0) Cr. 3. F.
Prerequisite: 432, credit or classification in Math. 321.
Analysis of framed structures by force and displacement methods; energy principles; treatment of nonprismatic members, semi-rigid connections, foundation settlements, temperature changes, composite structures.

536. BRIDGE DESIGN.
(3-0) Cr. 3. S.
Prerequisite: 433, 434, Math. 321.
Superstructure and substructure design. Design of simple span and continuous span bridges, including slab, beam and slab, and truss types. Introduction to orthotropic steel plate deck bridges.

538. MODEL ANALYSIS OF STRUCTURES.
(2-3) Cr. 3. W.
Prerequisite: 433, 434, Math. 321, 322.
Theoretical and experimental model analysis of structures. Use of devices and mechanisms for measuring load effects on plane and space structures.

539. PRESTRESSED CONCRETE STRUCTURES.
(3-0) Cr. 3. W.
Prerequisite: 434, Math. 321.
Principles of prestressed concrete with applications to structural design.

540. BEHAVIOR OF REINFORCED CONCRETE MEMBERS.
Cr. 3 to 6. F.
Prerequisite: 434, credit or classification in Math. 321.
Behavior and strength of reinforced concrete members by reviews of experimental and analytical investigations; flexure, axial load, shear, bond, torsion; combined loadings.

544. PLASTIC ANALYSIS AND DESIGN OF STRUCTURES.
(3-0) Cr. 3. W.
Prerequisite: 433, Math. 321.
Behavior of beams and frames in plastic range. Calculation of ultimate loads by statical and mechanism methods. Computation of deflections in elasto-plastic range and at ultimate. Secondary design considerations. Connections.

545. BEHAVIOR OF METAL STRUCTURES.
(3-0) Cr. 3. W.
Prerequisite: 433, Math. 321.
Study of the behavior of metals, connections, members, and structures; relation between results of research and current specifications for design.

546. ADVANCED STRUCTURAL DESIGN IN METALS.
(3-0) Cr. 3. S.
Prerequisite: 448.
Study of the theories of analysis of the behavior of structural metal members and the interpretation of specifications for the design of buildings and bridges.

547. PLATE AND SHELL TYPE STRUCTURES I.
(3-0) Cr. 3. S.
Prerequisite: 434, E.M. 514, Math. 322.
Bending and buckling of thin plates. Plate analysis by finite differences. Folded Plates. Analysis of cylindrical, spherical, and hyperbolic paraboloidal shells by membrane theory. Bending of cylindrical shells.

551. HIGHWAY ECONOMICS AND FINANCE.
(3-0) Cr. 3. F.
Prerequisite: 352 and Econ. 242; or Econ. 405 or I.Ad. 463 or I.E. 304.
Highway revenue sources, apportionment to different levels of government, allocation of taxation between highway users and nonusers and among classes of users. Principles of economic analysis for highway improvements, pertinent market and nonmarket benefits and costs, methods of analysis.

553. TRAFFIC ENGINEERING PLANNING AND ANALYSIS.
(3-3) Cr. 4. F.
Prerequisite: Credit or classification in 453.
Human and vehicular characteristics related to traffic; traffic characteristics; highway capacity; traffic studies and analysis of data; principles of traffic planning, forecasting techniques, and mass-transit planning.

554. TRAFFIC ENGINEERING DESIGN AND CONTROL.
(3-3) Cr. 4. W.
Prerequisite: 553.
Principles of street and highway traffic design for safety and control, arterial ways, one-way streets, traffic signals, signs, markings and lighting, channelization, speed regulation and zoning.

555. HIGHWAY AGENCY ADMINISTRATION AND MANAGEMENT.
Cr. 3. F.
Prerequisite: 352 or Pol.S. 471.
Organization of the highway function at national, state, and local levels; administrative procedures for highway planning, design, construction, operation, and maintenance. Management principles applicable to the highway function of governments and public authorities.

556. DESIGN OF AEROSPACE TRAFFIC AND TRANSPORTATION FACILITIES.
(3-3) Cr. 4. S.
Prerequisite: 453.
Historical development, legislation, finance, zoning and operation of aerospace transport facilities. The installation of lighting and electronic traffic aids for taxiways, runways, approaches and airways. The planning, location and design of heliports, airports, and spaceports.

560A. SOIL MECHANICS I.
(3-0) Cr. 3. F.
Prerequisite: 360.
Advanced treatment of theory and principles of engineering soil mechanics as related to permeability, capillarity, seepage forces, stress distribution, effective stresses, and shear strength.

560B. SOIL MECHANICS II.
(3-0) Cr. 3. W.
Prerequisite: 560A.
Advanced soil mechanics. Slope stability, earth pressures, bearing capacity, piles, and underground conduits.

562. AIRPHOTO INTERPRETATION OF ENGINEERING SOILS.
(2-6) Cr. 4. S.
Prerequisite: 360 and Geol. 301 or 302.
Recognition, identification, and mapping of engineering soils from airphotos. Site evaluation; material reconnaissance; principles and applications of infrared, radar, microwave technology; field checking.

563. ADVANCED SOIL ENGINEERING LABORATORY.
(2-3) Cr. 3. W.
Prerequisite: 565.
Analysis of engineering soils and crystalline materials by X-ray diffraction, differential thermal, and thermogravimetric methods.

564. ADVANCED SOIL ENGINEERING LABORATORY.
(1-6) Cr. 3. S.
Prerequisite: 560A.
Triaxial shear, consolidation, permeability, capillarity testing and analyses; relation of hydrostatic excess pressures to compositional influences. Field load tests.

565. STABILITY OF SOIL MATERIALS.
(3-0) Cr. 3. F.
Prerequisite: 360, 362.
Physico-chemical factors affecting soil stability; clay minerals, clay colloid chemistry and effect of chemical additives such as portland cement, lime salts, and resins.

567. CONCRETE MATERIALS.
(3-3) Cr. 4. F.
Prerequisite: 362, E.M. 354.
Theoretical and practical design of portland cement concrete mixtures. Rheology of fresh paste and concrete. Physical chemistry of hydrating cement paste and concrete, and the effects of admixtures. Architectural concrete. Nondestructive testing.

568. BITUMINOUS PAVING MATERIALS.
(3-3) Cr. 4. F.
Prerequisite: 362.
Source, manufacture, processing, types, constituents, tests, chemical behavior, specifications, and uses of bituminous materials and aggregates in pavement. Laboratory tests.

569. PAVEMENT DESIGN.
(3-0) Cr. 3. W.
Prerequisite: 567, 568.
Design of flexible and rigid pavements.

571. FIELD HYDROLOGY.
(2-3) Cr. 3. F.
Prerequisite: 304, E.M. 378.
Collection and analysis of field data concerning precipitation, water losses and stream flow. Use of current hydrologic techniques in hydrologic studies.

573. GROUND WATER HYDROLOGY.
(3-0) Cr. 3. S.
Prerequisite: 304, E.M. 378.
Study of ground water as a source of municipal, industrial, and agricultural water supplies; location, occurrence, hydraulics of flow; determination of aquifer and well characteristics, well discharge and pumping test analysis.

574. MULTIPLE USE OF WATER RESOURCES.
(2-3 to 12) Cr. 3 to 6. W.
Prerequisite: 304.
Social, economic, and technical phases of governmental participation in public works programs in the field of water resources. Study of multipurpose uses in water resources project planning.

585. HIGHWAY CONSTRUCTION METHODS.
(2-2) Cr. 3. F.
Prerequisite: 362, credit or classification in 485.
Methods and equipment used in processing materials and constructing highways and their appurtenances; scheduling and controlling operations; compliance with specifications.

586. HEAVY CONSTRUCTION METHODS.
(3-0) Cr. 3. W.
Prerequisite: Credit or classification in 485.
Methods and equipment employed in heavy construction including pile, caissons, heavy foundations, piers, coffer dams and river works, heavy concrete structures, retaining walls, tunneling, and dam projects.

590. SPECIAL TOPICS.
Cr. 1 to 5 each time elected.

COURSES FOR GRADUATE STUDENTS, major or minor

622. ADVANCED TOPICS IN WATER POLLUTION CONTROL.
Cr. 3 to 6. Alt. F, offered 1972.
Prerequisite: 522.
Study of advanced concepts in water pollution control. Analysis and application of current developments to pollution control methods.

623. ADVANCED TOPICS IN WATER TREATMENT.
Cr. 3 to 6. Alt. F, offered 1971.
Prerequisite: 523.
Study of advanced concepts in water treatment. Analysis and application of current developments to water treatment methods.

634. CABLE-SUPPORTED STRUCTURES.
(3-0) Cr. 3. W.
Prerequisite: 534, E.M. 345.
Comparison of analyses by elastic theory, conventional deflection theory, and difference equation methods as applied to suspension bridges. Consideration of other types of cable-supported structures.

644. SPACE FRAMES.
Cr. 3 to 6. F.
Prerequisite: 534.
Analysis of complete structures in three planes, including the continuous-frame and the truss-frame types.

646. DYNAMIC ANALYSIS OF STRUCTURES.
Cr. 3 to 6. S.
Prerequisite: 533 or 534; E.M. 345.
Single and multi-degree systems, linear and nonlinear systems, arbitrary disturbances, continuous and lumped mass systems, numerical and phase plane solutions, modal analysis, formulation by flexibility and stiffness matrices, response spectra, analysis and design for earthquake, wind, nuclear blasts, and moving vehicles.

648. PLATE- AND SHELL-TYPE STRUCTURES II.
(3-0) Cr. 3. F.
Prerequisite: 547.
Introduction to finite-element method. Influence surfaces for bending of plates. General theory of thin shells. Analysis and design of domes, shell walls, and cylindrical shell roofs.

653. STREET AND URBAN HIGHWAY DESIGN.
(3-3) Cr. 4. W.
Prerequisite: 553.
Design of city streets, involving cross section, intersections, subsurface utilities, on- and off-street parking, mass transportation, loading facilities, widening, channelization, drainage, and markings; design of urban expressways, service roads and their relationship to basic street system.

654. HIGHWAY LOCATION AND DESIGN.
Cr. 4. S.
Prerequisite: 554.
Route selection, geometric design, economic aspects, traffic capacity, and roadway appurtenances of nonurban roads and highways.

656. PLANNING TRANSPORTATION SYSTEMS.
Cr. 3. Alt. S, offered 1973.
Prerequisite: 553.
Fundamentals and coordination of transportation systems. Regional planning, planning surveys, designation of road and street systems. Mass transportation and location and type of urban facilities.

660. FOUNDATIONS AND UNDERGROUND STRUCTURES.
(3-0) Cr. 3. S.
Prerequisite: 560B.
Advanced foundation analysis and design to meet various soil conditions. Review of recent literature. Field investigation. Case histories.

663. EARTH DAMS.
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: 560B.
Location, selection of material, design, and construction of earth dams. Field trips.

664, 665, 666. STABILITY OF SOILS AND GRANULAR MATERIALS.
(3-0) Cr. 3. Alt. Yr, offered 1972-73.
Prerequisite: 565.
Granulometry and colloid chemistry as related to soil plasticity classification, strength, and mix design. Use of chemical stabilizers, pozzolans, and portland cement.

669. ADVANCED PAVEMENT DESIGN.
(3-0) Cr. 3. Alt. S, offered 1973.
Prerequisite: 569.
Recent developments in the theories of flexible and rigid pavement design. Test road evaluations.

671. ADVANCED TOPICS IN WATER RESOURCES ENGINEERING.
(A.E. 671) (3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: 571; 472 or A.E. 424; Stat. 401.
Study of advanced concepts and experimental techniques used in solving water resources engineering problems. Application of simulation methods, mathematical models and advanced research methods in areas of hydrology, hydraulics of water control facilities, and water-resources development.

691. SEMINAR.
Cr. R.

699. RESEARCH.

COMPUTER SCIENCE

Robert M. Stewart, Jr., Ph.D., Chairman of Department

The Graduate Faculty

Members: R.F. Keller, R.J. Lambert, C.G. Maple, A.V. Pohm, D.H. Schuster, R.M. Stewart

Associate Members: H.C. Brearley, D.D. Grosvenor, N.E. Hutton, H.W. Jesperson, A.E. Oldehoeft, S.M. Silverston, J.D. Stevens, G.O. Strawn, R.A. Thomas, D.L. Ulrichson, C.T. Wright, Jr., R.J. Zingg

Work is offered for the degrees Master of Science and Doctor of Philosophy with major in computer science. Minor work is offered to students taking major work in other areas.

Facilities exist for fundamental research in such areas as numerical solution of ordinary and partial differential equations, computational methods in linear algebra, the theory of approximation, logical design and programming systems, switching theory, the theory of computer organization, programming language theory, and computer-assisted instruction.

A student desiring to do graduate work with a major in computer science should have completed a bachelor's degree or equivalent in computer science or in a related area such as mathematics, statistics, physics, or electrical engineering. He should have a strong background in mathematics including some work in algebra, analysis, logic, and probability. Students who do not have these prerequisites should plan to complete them in addition to the regular course requirements for the advanced degree.

For the degree Master of Science, 45 quarter credits are required. Normally this is all in course work, but in some cases it will include preparation of a thesis recommended by the student's advisory committee. If no thesis is presented, the preparation of a paper demonstrating ability to organize and express significant ideas in computer science is required. There is no foreign language requirement.

For the degree Doctor of Philosophy, the foreign language requirement may be satisfied in one of two ways: (1) Significant competence in one language. This competence may be evidenced by satisfactory completion of two years of college level study of the language. (2) Reading ability in two languages. Ability in each language may be evidenced by satisfactory completion of one year of college level study of the language. In exceptional cases the candidate's committee may authorize the passing of a standardized foreign language examination in lieu of a formal college-level course in the language.

The languages will normally be selected from French, German, or Russian, although the candidate's committee may authorize other choices. The committee of a student whose native language is not English may substitute the ability to communicate in English for one of two languages.

The Department of Computer Science recommends that all graduate students majoring in computer science teach as part of their training for an advanced degree.

Additional work is usually required in mathematics, statistics, electrical engineering, or certain other fields.

COURSES FOR GRADUATE STUDENTS, major or minor

301. MACHINE AND ASSEMBLY LANGUAGE PROGRAMMING.
(3-0) Cr. 3. F.S.
Prerequisite: 202.
Introduction to digital computer structure and machine language programming, internal representation of data, assembly language.

350. INFORMATION STRUCTURES.
(3-0) Cr. 3. F.S.
Prerequisite: 203.
Study of information representations and relationship between the form of representations and processing techniques. Transformations between storage media; referencing of information as related to the structure of its representation. Concepts of functions, arrays, records, files, trees, list and list structures.

356. COMPUTER SYSTEMS I.
(3-0) Cr. 3. F.W.
Prerequisite: 301.
Assembly systems, storage allocation and protection techniques, executive systems-structures, generation and maintenance; priority and scheduling techniques for batch processing.

357. COMPUTER SYSTEMS II.
(3-0) Cr. 3. W.S.
Prerequisite: 356.
Executive systems for multiprogramming and multiprocessing, input-output control, dynamic storage allocation, interrupts, program library maintenance and up-dating, time-sharing systems.

380. STATISTICAL APPLICATIONS OF DIGITAL COMPUTERS.
(Stat. 380) See Statistics.

406. INTRODUCTION TO NUMERICAL TECHNIQUES FOR COMPUTERS.
(Math. 406) See Mathematics.

407, 408. NUMERICAL ANALYSIS I, II.
(Math. 407, 408) See Mathematics.

410. INTRODUCTION TO SWITCHING THEORY.
(E.E. 410) See Electrical Engineering.

411, 412. PRINCIPLES OF COMPUTER DESIGN.
(E.E. 411, 412) See Electrical Engineering.

441. COMPUTER-ORIENTED BUSINESS DATA SYSTEMS I.
(2-3) Cr. 3. F.
Prerequisite: Credit or classification in I.Ad. 384.
Mosier, Ostendorf.
Introduction to computer techniques for business data processing. Use of COBOL programming language in simple problems, payroll, inventory control, etc.

442. COMPUTER-ORIENTED BUSINESS DATA SYSTEMS II.
(2-3) Cr. 3. W.
Prerequisite: 441 and credit or classification in I.Ad. 385. Ostendorf.
Application of computer programming and systems to business data processing; file organization, development, and control; sequential and random processing and exception reporting.

443. COMPUTER-ORIENTED BUSINESS DATA SYSTEMS III.
(2-3) Cr. 3. S.
Prerequisite: 442. Ostendorf.
Advanced data systems concepts and processing techniques. On-line, off-line systems and controls; computer language and operating systems considerations in business data processing; Pert CPM and management game concepts.

447. INTRODUCTION TO COMPUTERS FOR THE BIOLOGICAL RESEARCH WORKER.
(V.Pth. 447) (3-0) Cr. 3. F. Hutton.
Data coding and use of unit record equipment. Logical basis of a digital computer system. The programming of data editing and record keeping procedures will be taught using a higher level language.

451. ALGEBRAIC LANGUAGES AND COMPILERS I.
(3-0) Cr. 3. F.W.
Prerequisite: 202. Keller.
Introduction to languages in general, formal language structure (syntax and semantics).

452. ALGEBRAIC LANGUAGES AND COMPILERS II.
(3-0) Cr. 3. W.S.
Prerequisite: 451. Keller.
Study of Backus Normal (Naur) Form and introduction to compiling; compiler construction; analyzer algorithms.

453. ALGEBRAIC LANGUAGES AND COMPILERS III.
(3-0) Cr. 3. S.
Prerequisite: 452. Keller.
Compiling techniques, code generation.

468. PROBLEM FORMULATION IN NON-NUMERIC PROCESSES.
(3-0) Cr. 3. W.
Prerequisite: 350.
Techniques for solving non-numeric problems. Problem organization, modelling, data structuring, and language features dictated by non-numeric problems. Theorem proving, game playing, natural language processing, symbolic mathematics and man-machine problem solving.

470. INTRODUCTION TO DATA PROCESSING AND PROGRAMMING FOR BEHAVIORAL SCIENCES.
(3-0) Cr. 3. F.
Prerequisite: Stat. 401.
Concepts and procedures. Punch card concepts, data organization and collection, storage media, and computer organization. Program organization and flowcharting techniques. Primarily for research workers in behavioral sciences.

471. DATA PROCESSING AND PROGRAMMING FOR BEHAVIORAL SCIENCES.
(3-0) Cr. 3. W.
Prerequisite: 470.
Use of data-processing techniques and the computer as research tools. Higher-level language programming and use of mathematical and statistical library programs.

481, 482. PROCESSING OF STATISTICAL DATA.
(Stat. 481, 482) See Statistics.

484. COMPUTER TECHNIQUES FOR BIOLOGICAL RESEARCH.
(3-0) Cr. 3. S.
Prerequisite: 201, Stat. 401.
Review of input-output devices, array manipulation, and subroutine usage. Organization of large-volume data for using mathematical and statistical library programs.

490. SPECIAL PROBLEMS.
Cr. var.
Prerequisite: Permission of instructor.
H. Honors Program.

495. SEMINAR.
Cr. var. F.W.S.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

501, 502, 503. PROGRAMMING LANGUAGES AND SYSTEMS.
(3-0) Cr. 3 each. Yr.
Prerequisite: 453.
Formal approach to programming languages.

507, 508. NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS.
(Math. 507, 508) See Mathematics.

509. COMPUTATIONAL METHODS OF LINEAR ALGEBRA.
(Math. 509) See Mathematics.

524, 525. THEORY OF AUTOMATA.
(Math. 524, 525) See Mathematics.

551, 552, 553. STRUCTURE AND PROCESSING OF INFORMATION.
(3-0) Cr. 3. Yr.
Prerequisite: 350. Jespersen.
Formalisms necessary to represent the structure and manipulation of information. Information coding for storage and retrieval, fixed and variable length information records; vectors and arrays; trees and list structures. Processing of structured information. Search, sort, and merge operations involving the characteristics of the storage media available in a computer system. Characteristics of programming languages for processing information structures; study of at least one current information processing language.

580, 581. SCIENTIFIC APPLICATION OF DIGITAL COMPUTERS, I, II.
(Stat. 580, 581) See Statistics.

582. SWITCHING THEORY.
(E.E. 582) See Electrical Engineering.

584, 585. DIGITAL SYSTEM ORGANIZATION.
(E.E. 584, 585) See Electrical Engineering.

586. DIGITAL SYSTEM DESIGN.
(E.E. 586) See Electrical Engineering.

590. SPECIAL TOPICS.
Cr. var.
Prerequisite: Permission of instructor.

COURSES FOR GRADUATE STUDENTS, major or minor

607. ADVANCED TOPICS IN NUMERICAL ANALYSIS.
(Math. 607) See Mathematics.

610. SEMINAR.
Cr. var. Offered on demand.

684. ADVANCED SWITCHING THEORY.
(E.E. 684) See Electrical Engineering.

685. ADVANCED LOGIC SYSTEMS.
(E.E. 685) See Electrical Engineering.

699. RESEARCH.

CONSTRUCTION ENGINEERING

Thomas C. Jellinger, M.S., Professor in Charge

The Department of Civil Engineering provides a curriculum for those students who are interested in construction engineering.

COURSES FOR GRADUATE STUDENTS, minor only

355. REAL ESTATE FINANCE.
(I.Ad. 355) See Industrial Administration.

371. CONTRACTORS ORGANIZATION.
(3-0) Cr. 3. F.W.
Prerequisite: 246.
Construction contracting business management: planning, organization, staffing, directing, controlling.

372. CONSTRUCTION PLANNING AND PROGRESS SCHEDULING I.
(0-9) Cr. 3. W.S.
Prerequisite: 371.
Types of progress schedules used in construction work. Applications and advantages of types of schedules. Principles of planning construction site layouts along with methods used in field inspection.

441. CONSTRUCTION PROGRESS SCHEDULING II.
(0-9) Cr. 3. F.
Prerequisite: 372.
Analysis and application of advanced scheduling techniques with emphasis on critical path method (CPM) and program evaluation and review (PERT).

442. CONSTRUCTION PROGRESS SCHEDULING III.
(0-9) Cr. 3. W.
Prerequisite: 441, Com.S. 201.
A study of computer methods and applications of advanced techniques of construction scheduling with work in man-power leveling, equipment allocation, and time-cost relationships.

450. QUANTITATIVE METHODS IN CONSTRUCTION MANAGEMENT.
(3-0) Cr. 3. S.
Prerequisite: 442, Stat. 105.
Analysis of construction management problems using mathematical and statistical techniques; adaptation of utility and risk functions and linear programming to construction management: decision making, statistical bidding, theory and application of bidding strategy.

EARTH SCIENCE

Keith M. Hussey, Ph.D., Head of Department

The Graduate Faculty

Members: D.L. Biggs, C.S. Gwynne, K.M. Hussey, J. Lemish, C.J. Roy, K.E. Seifert, C.F. Vondra, D.N. Yarger

Associate Members: W.G. Biggs, R.D. Cody, R.C. Palmquist, L.V.A. Sendlein

The department offers work for the degrees Master of Science and Doctor of Philosophy with majors in earth science, geology, and meteorology, and minor work to students majoring in other departments. A nonthesis option is offered for the degree Master of Science in earth science and in meteorology. Geology majors interested in a broader program may obtain the

degree Doctor of Philosophy with a major divided between geology and a related field. The department also cooperates in an interdepartmental program leading to the degrees Master of Science and Doctor of Philosophy in water resources with major work in geology and subordinate work in other fields. See *Water Resources.*

Students desiring to major in earth science, geology, meteorology, or water resources should have mathematics through calculus and one year each of college physics and college chemistry in addition to some background in earth science.

The department requires no foreign language proficiency for the M.S. degree. Candidates for the Ph.D. degree are required to submit proof of reading knowledge of two foreign languages or reading and speaking knowledge of one. The candidate's graduate committee may accept, as proof of mastery, either course grades in language courses taken at Iowa State University or examination scores of comprehensive examinations administered by the Foreign Language Department.

Course programs are arranged on an individual basis. Minor work is normally recommended in chemistry, computer science, engineering mechanics, mathematics, metallurgy, physics, soils, soils engineering, or zoology.

GEOGRAPHY

COURSES FOR GRADUATE STUDENTS, minor only

322. **ECONOMIC GEOGRAPHY.**
(3-0) Cr. 3. Alt. W, offered 1973.
Character and distribution of natural resources; their influence on man and their utilization by man.

324. **CULTURAL GEOGRAPHY—EUROPEAN AND AMERICAN.**
(3-0) Cr. 3. W.
Climate and physical geography of Europe, and North, Central, and South America, and their influence on the cultural development of man in those areas.

325. **CULTURAL GEOGRAPHY—AFRICAN, ASIAN, AUSTRALIAN, AND PACIFIC ISLANDS.**
(3-0) Cr. 3. S.
Climate and physical geography of Africa, Asia, Australia, and the Pacific Islands; their influence on the cultural development of man in those areas.

421. **SETTLEMENT GEOGRAPHY.**
(3-0) Cr. 3. Alt. W, offered 1972.
Prerequisite: 201.
Evolution, morphology, and spatial distribution of urban and rural settlement with an emphasis on North America and Europe.

490. **SPECIAL PROBLEMS.**
Cr. 2 to 4 each time taken.
Prerequisite: 201, permission of instructor.

GEOLOGY

COURSES FOR GRADUATE STUDENTS, minor only

302. **SUMMER FIELD WORK.**
Cr. 8 to 12. SS.
Prerequisite: 204, 271. Vondra.
An eight-week summer field course, required of all geology majors. Areal mapping, structural, stratigraphic, and geomorphic analyses. Written reports with appropriate illustration required.

340. **INTRODUCTION TO GEOPHYSICS.**
(3-0 or 6) Cr. 3 or 5. S.
Prerequisite: 302; Phys. 113 or 223. Sendlein.
Application of physical principles to the determination of subsurface rock structure and/or boundaries. Includes seismology, gravitometry, magnetometry, and the techniques of electrical and radioactivity surveying. Field application of geophysical methods to include data acquisition, and computer processing and interpretation.

351. **MINERALOGY.**
(3-6) Cr. 5. F.
Prerequisite: Chem. 142. D.L. Biggs.
Geochemistry of silicates and other rock-forming minerals; determinative mineralogy; elementary optical crystallography.

361. **INVERTEBRATE PALEONTOLOGY.**
(2-6) Cr. 4. S.
Prerequisite: 100. Vondra and Cody.
Characteristics and relationships of invertebrates of fossil record; their use in historical geology. Field trips.

371. **PETROLOGY.**
(2-6) Cr. 4. S.
Prerequisite: 351, Math. 112. Seifert.
Origin, properties, and behavior of rocks as a function of their environment. Microscopic description and classification of rocks. Field trips.

381. **STRUCTURAL GEOLOGY.**
(3-3) Cr. 4. W.
Prerequisite: 100, 271. Lemish.
Theory of rock deformation. Description and classification of structures in the earth's crust. Application of descriptive geometry and map interpretation techniques to solution of structural problems.

400. ADVANCED FIELD GEOLOGY.
Cr. 8 to 12. SS.
Prerequisite: 371, 381. Vondra.
An eight-week field course for the advanced geology major, emphasizing advanced field techniques and providing the student with experience in analyzing geologic field problems.

401. GEOLOGY OF EASTERN NORTH AMERICA.
(3-0) Cr. 3. Alt. W, offered 1972.
Prerequisite: 371, 381. Seifert.
Coastal Plains, Appalachians, West Indies, Central Interior, and Canadian Shield.

402. GEOLOGY OF WESTERN NORTH AMERICA.
(3-0) Cr. 3. Alt. W, offered 1973.
Prerequisite: 371, 381. Seifert.
Rockies, Basin and Range, Sierra Nevadas, Cascades, and Coast Ranges.

407. GEOLOGIC INTERPRETATION OF AERIAL PHOTOGRAPHS.
(1-6) Cr. 3. Alt. F, offered 1971.
Prerequisite: 100. Palmquist.
Principles of aerial photography and imagery used in qualitative and quantitative analysis of geologic features from aerial photographs.

411. PRINCIPLES OF ECONOMIC GEOLOGY.
(3-3) Cr. 4. F.
Prerequisite: 371, 381. Lemish.
Nature and origin of mineral deposits.

431. GEOMORPHOLOGY.
(3-3) Cr. 4. F.
Prerequisite: 100, Stat. 101. Palmquist.
Interrelationship between geomorphic processes and earth materials in development of landforms; use of landforms in interpretation of recent geologic history. Saturday field trips.

440. PETROPHYSICS.
(2-6) Cr. 4. W.
Prerequisite: 302, 371, 381, Math. 213, Phys. 223. Sendlein.
Physical properties of rocks, including porosity, permeability, elastic properties, and heat and electrical conductivity. Rocks studied through laboratory investigations to establish their relationship to natural geologic materials and processes.

452. OPTICAL MINERALOGY.
(2-6) Cr. 4. W.
Prerequisite: 351. D.L. Biggs.
Relationships of structure, symmetry, and optical properties of transparent crystals. Study of principal rock-forming minerals with polarizing microscope.

490. SPECIAL PROBLEMS.
Cr. 2 to 4 each time taken.
Prerequisite: 100, permission of instructor.

492. STRATIGRAPHY.
(3-3) Cr. 4. F.
Prerequisite: 361, 371, 381. Vondra.
Principles of stratigraphy and their application to and exemplification by geologic occurrences.

COURSES FOR GRADUATE STUDENTS, major or minor

501. SEMINAR.
Cr. 1 each time taken. F.W.S.
Prerequisite: Permission of instructor.

512. ADVANCED ECONOMIC GEOLOGY.
(3-0) Cr. 3. Alt. W, offered 1973.
Prerequisite: 411. Lemish.
Geology applied to mining; significant deposits and districts.

515. GEOCHEMISTRY.
(3-6) Cr. 5. Alt. F, offered 1971.
Prerequisite: Chem. 211, 301; permission of instructor. Lemish.
Emphasis on chemistry of geological processes related to changes in earth materials.

521. SEDIMENTATION.
(3-4) Cr. 5. Alt. W, offered 1972.
Prerequisite: 492, 515. Cody.
Survey of sedimentation processes with emphasis on clastic sedimentation.

531. QUATERNARY GEOLOGY.
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: 431. Palmquist.
Use and interpretation of variations in character of landforms, sediments, and fossils in reconstruction of Quaternary events and environments. Saturday and weekend field trips.

532. DYNAMICS OF GEOMORPHIC SYSTEMS.
(2-1) Cr. 3. Alt. S, offered 1973.
Prerequisite: 431. Palmquist.
Analysis of geomorphic systems acting under various constraints and of the resulting landforms.

535. GROUNDWATER GEOLOGY.
(2-3) Cr. 3. Alt. W, offered 1972.
Prerequisite: 440, C.E. 304. Sendlein.
Occurrence and distribution of subsurface water; nature of conducting media.

551. ADVANCED MINERALOGY.
(2-3) Cr. 3. Alt. S, offered 1972.
Prerequisite: 452. D.L. Biggs.
Structural, chemical, and paragenetic relationships of common rock-forming minerals.

561. VERTEBRATE PALEONTOLOGY.
(3-3) Cr. 4. Alt. F, offered 1971.
Prerequisite: 361, Zool. 320. Vondra.
Morphology (cranial, dental, and post-cranial), taxonomy, evolution, and distribution of fossil vertebrates with emphasis on mammals.

565. ADVANCED INVERTEBRATE PALEONTOLOGY.
(2-6) Cr. 4. Alt. W, offered 1973.
Prerequisite: 361. Cody, Vondra.
Selected topics in paleontology and paleoecology: sedimentary environments and their effects on organisms, stratigraphic correlation, interpretation of earth history, advanced morphologic descriptions of fossils.

571. IGNEOUS PETROLOGY.
(2-6) Cr. 4. Alt. F, offered 1972.
Prerequisite: 371, Math. 213. Seifert.
Review of igneous petrology; discussion of field observations and laboratory data. Emphasis on approach to equilibrium. Study of selected igneous rocks.

575. METAMORPHIC PETROLOGY.
(2-6) Cr. 4. Alt. F, offered 1971.
Prerequisite: 371, Math. 213. Seifert.
Review of metamorphic petrology with discussion of field observations and laboratory data. Emphasis on approach to equilibrium. Study of selected metamorphic rocks.

581. **ADVANCED STRUCTURAL GEOLOGY.**
(2-3) Cr. 3. Alt. F, offered 1972.
Prerequisite: 381. Lemish.
Current theories of rock deformation and advanced problems in metamorphic, igneous and sedimentary structures.

590. **SPECIAL TOPICS.**
Cr. 1 to 3 each time taken.
A. Geomorphology.
B. Stratigraphy.
C. Paleontology.
D. Petrology and Mineralogy.
E. Structural Geology.
F. Geochemistry.
G. Water Resources.
H. Earth Science.
I. Sedimentation.
J. Economic Geology.
K. Rock Deformation.
L. Geophysics.

592. **ADVANCED STRATIGRAPHY.**
(3-2) Cr. 4. Alt. F, offered 1972.
Prerequisite: 492, 521. Vondra.
Interpretation of sedimentary rocks and rock bodies to infer processes, environments, and tectonic settings under which they formed. Major facies of Cenozoic deposits of selected regions studied and analyzed.

COURSES FOR GRADUATE STUDENTS, major or minor

651. **CLAY MINERALOGY.**
(2-3) Cr. 3. Alt. W, offered 1972.
Prerequisite: 551, Chem. 323. D.L. Biggs.
Geological significance, structure, and chemistry of clay minerals.

672. **ADVANCED SEDIMENTARY PETROLOGY.**
(2-6) Cr. 4. Alt. S, offered 1973.
Prerequisite: 571. D.L. Biggs.
Advanced study of petrology and petrography of sedimentary rocks. Field trips.

675. **ROCK DEFORMATION.**
(2-6) Cr. 4. Alt. W, offered 1972.
Prerequisite: 581, Math. 213. Seifert.
Theory and experimental conditions for rock deformation; stress-strain relations. Deformation of selected rocks.

678. **DEFORMATION OF MINERALS.**
(2-6) Cr. 4. Alt. S, offered 1973.
Prerequisite: 571, Math. 213. Seifert.
Analysis of deformation in rock-forming minerals; interpretation in terms of petrogenesis; plastic flow at elevated temperatures and pressures. Universal stage identification of deformation mechanisms.

685. **GEOTECTONICS.**
(3-0) Cr. 3. Alt. W, offered 1972.
Prerequisite: 371, 381, 492. Hussey, Roy.
Distribution and dynamic history of sedimentary basins and mountain ranges of the world.

699. **RESEARCH.**
Cr. 1 to 3 each time taken.
A. Geomorphology.
B. Stratigraphy.
C. Paleontology.
D. Petrology and Mineralogy.
E. Structural Geology.
F. Geochemistry.
G. Water Resources.
H. Earth Science.
I. Sedimentation.
J. Economic Geology.
K. Rock Deformation.
L. Geophysics.

METEOROLOGY

COURSES FOR GRADUATE STUDENTS, minor only

406. **CLIMATES OF THE CONTINENTS.**
(Agron. 406) See Agronomy.

421. **METEOROLOGICAL INSTRUMENTS.**
(2-3) Cr. 3. W. Vaughan.
Prerequisite: Three credits of meteorology, Math. 112; Phys. 112 or 223.
Theory and techniques of conventional meteorological instruments. Limitations of specific instruments and systems encountered in field and laboratory measurements. Emphasis on theory and calibration of instruments.

441, 442, 443. **INTRODUCTION TO THEORETICAL METEOROLOGY I, II, III.**
(4-0) Cr. 4 each. Yr. Yarger.
Prerequisite: 441: Phys. 112 or 223; Math. 112; 442: 441; 443: 442.
441: Thermodynamics: Equation of state, first law of thermodynamics, thermodynamics of water vapor, mixtures of gases, thermodynamic diagrams; 442: Dynamics: Equations of motion on a rotating earth, horizontal motion, kinematics of fluid flow, circulation, vorticity and divergence, equation of continuity, thermal wind; 443: Physical: Basic radiation laws, cloud physics, atmospheric electricity.

455, 456. **SYNOPTIC METEOROLOGY I, II.**
(1-6) Cr. 3 each. 455: W; 456: S.
Prerequisite: 455: 302; 456: 455. Barnard.
Construction of meteorological charts for forecasting weather elements; kinematic analysis, air mass analysis, fronts and pressure systems, graphical determination of thickness patterns, interpretation of centrally prepared weather charts.

490. **SPECIAL PROBLEMS.**
Cr. var.
Prerequisite: Permission of instructor.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

505. **MICROCLIMATOLOGY.**
(Agron. 505) See Agronomy.

506. **METHODS IN CLIMATOLOGY.**
(Agron. 506) See Agronomy.

521. **ADVANCED INSTRUMENTATION.**
(2-3) Cr. 3. Alt. S, offered 1972.
Prerequisite: Three credits of meteorology, Math. 213, Phys. 223. Vaughan.
Theoretical treatment of meteorological instruments and systems with particular emphasis on research instruments for micrometeorological measurements. Survey of transducer types available, their responses and limitations.

542. **PHYSICAL METEOROLOGY.**
(3-0) Cr. 3. F.
Prerequisite: Phys. 223, Math. 213. Yarger.
Wave phenomena, propagation of energy through the atmosphere, atmospheric optics, visibility, scattering phenomena, the upper atmosphere.

543, 544. **DYNAMIC METEOROLOGY I, II.**
(4-0) Cr. 4 each. 543: W; 544: S.
Prerequisite: 543: 443; 544: 543.
543: Fundamental equations, manipulations, magnitudes, and transformations. 544: The solution problem. Particle dynamics, perturbation, and numerical methods.

571, 572. **CLOUD PHYSICS I, II.**
(3-0) Cr. 3 each. 571: Alt. W, offered 1973; 572: Alt. S, offered 1973.
Prerequisite: 443. Yarger.
571: Cloud dynamics, thermodynamics of phase-change and nucleation, numerical techniques in cloud physics, condensation nuclei and ice nuclei, diffusional growth of cloud drops and ice crystals. 572: Ice crystals and coalescence theories of initiation of precipitation, aerodynamic theory, accretional growth of raindrops and ice particles, cloud modification techniques.

590. **SPECIAL TOPICS.**
Cr. var.
Prerequisite: Permission of instructor.

COURSES FOR GRADUATE STUDENTS, major or minor

605. **MICROMETEOROLOGY.**
(5-0) Cr. 5. Alt. F, offered 1971.
Prerequisite: 505; 442 or E.M. 378. W.G. Biggs.
Physical processes in the atmosphere near the ground; laminar and turbulent flow; transfer of heat, mass, and momentum; eddy diffusion; statistical theories of turbulence; wind and temperature profiles near the surface; evaporation.

610. **ATMOSPHERIC TURBULENCE AND DIFFUSION.**
(4-0) Cr. 4. Alt. F, offered 1971.
Prerequisite: 605. W.G. Biggs.
Analysis and statistics of atmospheric turbulence, theoretical treatment of atmospheric diffusion, K-theory, effects of buoyant motion, estimation of diffusion from meteorological data.

641, 642. **ATMOSPHERIC RADIATION.**
(3-0) Cr. 3 each. 641: Alt. W, offered 1972; 642: Alt. S, offered 1972.
Prerequisite: 641: 443, Phys. 548; 642: 641. Yarger.
Solar and terrestrial radiation, radiative transfer equation, atmospheric radiation charts, Stokes parameters, polarization.

699. **RESEARCH.**
Cr. var.
Prerequisite: Permission of instructor.

ECONOMICS

Karl A. Fox, Ph.D. Head of Department

The Graduate Faculty

Members: R.R. Beneke, E.A. Brady, H.S. Cheng, J.W. Christian, H.W. Davey, L.B. Fletcher, K.A. Fox, W.A. Fuller, N.E. Harl, E.O. Heady, B.R. Holdren, E.E. Hoyt, D.R. Kaldor, G.W. Ladd, M.I. Liston, D.G. Luckett, W.C. Merrill, C.W. Meyer, W.G. Murray, A.A. Paulsen, J.R. Prescott, F. Robotka, J.K. Sengupta, G.S. Shepherd, D.R. Starleaf, J.A. Stephenson, E. Thorbecke, J.F. Timmons, P.L. Van Moeseke

Associate Members: I.W. Arthur, A.G. Ball, C.P. Baumel, P.D. Doak, E.W. Eldridge, A.M. Faden, G.A. Futrell, C.P. Gratto, S.C. James, M.G. Julius, R.C. Maxon, L.V. Mayer, R.E. Raikes, J.T. Scott, J.M. Skadberg, J.R. Strain, R.W. Thomas, H. Van de Wetering, R.N. Wisner

The department offers work for the degrees Master of Science and Doctor of Philosophy with majors in economics and agricultural economics, and minor work to students taking major work in other departments.

Candidates for the degree Master of Science are required to complete satisfactorily 45 credits of acceptable graduate work including preparation of a thesis.

With the approval of the advisory committee, candidates for the degree Master of Science may fulfill requirements by completing satisfactorily 54 credits of course work, in which case preparation of a thesis is not required.

Prerequisite to major work in the department is the completion of undergraduate work in economics, mathematics, statistics, and other social science and technical subjects substantially equivalent to that required of undergraduate students majoring in economics or agricultural business.

There is no foreign language requirement for the degree Master of Science.

Programs of study for Ph.D. degrees are organized by each student in consultation with his major professor and his advisory committee. Students may select fields of concentration from the following:

Advanced Economic Theory
Agricultural Marketing and Price Analysis
Agricultural Development, Trade, and Policy
Agricultural Finance and Land Valuation
Econometrics
Economic Planning and Development
Industrial Organization
International Economics
Labor Economics
Monetary Economics
Operations Research
Production Economics and Farm Management
Public Finance and Fiscal Policy
Regional-Urban Economics
Resource Economics and Area Development

Each student is expected to achieve a minimum competence in economic theory as demonstrated by completing basic and advanced courses in microeconomic and macroeconomic theory and by completing a preliminary written examination. Examinations are also required in two other fields selected from the list above. An outside minor, such as statistics, mathematics, or computer science, can be substituted for one of the fields.

The language requirements for the Ph.D. degree may be satisfied by one language at a high level of competence, by two languages at a lower level, or by substitution of additional coursework outside of the major, minor, and primary supporting fields.

Cooperative programs of study may be arranged with the University of Iowa College of Law or with other recognized institutions.

The department is a cooperative department in the industrial relations program. See *Industrial Relations*.

COURSES FOR GRADUATE STUDENTS, minor only

307, 308. PRICES AND RESOURCE ALLOCATION.
(3-0) Cr. 3 each. 307: F.W.SSI; 308: W.S.SSII.
Prerequisite: 307: 242; 308: 307.
Theory of consumption and of the business firm; competitive and monopolistic markets; distribution of income; general equilibrium of the pricing system.

403. MARKETING LIVESTOCK AND MEAT.
(3-0) Cr. 3. S.
Prerequisite: 242.
The demand, supply, and distribution of livestock and meat. Analysis of changes in marketing methods; grades, values, prices, and costs. Visits to marketing agencies and firms.

405. PUBLIC FINANCE.
(3-0) Cr. 3. F.W.S.
Prerequisite: 242.
Principles of taxation; federal, state, and local revenue and expenditure policies; current issues in public finance.

409. NATIONAL INCOME AND EMPLOYMENT.
(3-0) Cr. 3. F.W.S.SSI.
Prerequisite: 242.
National income accounting. Static and dynamic theories of the determination of national income and employment and of business fluctuations. Monetary and fiscal policies for promoting economic stability and growth.

410. INDUSTRIAL STRUCTURES AND COMPETITION.
(3-0) Cr. 3. S.
Prerequisite: 308.
Measurement of structure, conduct, and performance of industries. Analysis of American antitrust laws and government regulation of industries.

411. ECONOMICS OF UNDERDEVELOPED NATIONS.
(3-0) Cr. 3. F.
Prerequisite: 242.
Analysis of capital formation and capital allocation problems; relation of transportation, communications, and resource availability to development; population and education problems as they relate to growth.

412. ECONOMICS OF AGRICULTURAL DEVELOPMENT.
(3-0) Cr. 3. W.
Prerequisite: 242; 330 or 436.
Less-developed economies; share and role of agriculture in labor force and national income; structure of agriculture; subsistence and commercial sectors; population, food, and nutrition; institutional considerations; policies for development; aid and international trade.

421. AGRICULTURAL COOPERATION.
(3-0) Cr. 3. W.
Prerequisite: 242.
General survey of cooperative activities, with special reference to agriculture; kinds of cooperatives, methods of organization and operation; principles, legal requirements; economic possibilities and limitations of cooperation.

430. ADVANCED FARM ORGANIZATION AND MANAGEMENT.
(2-2) Cr. 3. F.W.S.
Prerequisite: 242; 130 or 330.
Applications of budgeting and linear programming to planning organizations for varying soil, market, capital, tenure, and farm-size situations.

434. NATURAL RESOURCE ECONOMICS.
(3-0) Cr. 3. F.S.
Prerequisite: 242.
Natural resources, including soil, water, forests, minerals, air, and location, in the production process. Natural resources and population interrelationships. Types and intensities of uses, including urban, recreational, agricultural, industrial, and transportation. Private and public interests, ownerships, tenancy, and transfers. Use and tenure policies. Conservation.

435. AGRICULTURAL FINANCE.
(3-0) Cr. 3. W.
Prerequisite: 242.
Financial requirements of individual farmers and principles applicable to borrowing by farms and farm cooperative organizations. Analysis of lending agencies including commercial banks, insurance companies, merchants and dealers, Farm Credit Banks, and Farmers Home Administration.

436. AGRICULTURAL MARKETING ANALYSIS.
(3-0) Cr. 3. W.
Prerequisite: 335.
Analysis of demands, costs, and efficiency in agricultural marketing, processing, and farm-supply organizations. Analysis of the price-making processes as related to agricultural commodities. Effects of industry organization and government programs.

440. APPRAISAL OF FARM REAL ESTATE.
(2-3) Cr. 3. S.
Prerequisite: 242, Agron. 154.
Land appraisal with emphasis on valuation procedure. Relationship of farm prices, taxes, and interest rates to value. Appraisal reports.

441. MANPOWER ECONOMICS.
(3-0) Cr. 3. W.
Prerequisite: 305.
Wage theories and processes of wage determination; economic and institutional forces determining the level and composition of labor supply and demand; manpower implications of automation; labor mobility; governmental manpower policies.

444. MANAGEMENT: THEORY AND PRACTICE.
(3-0) Cr. 3. F.W.S.
Prerequisite: 307; Math. 110 recommended.
An analytical approach to business management. Business decision making with the aid of organization theory, linear programming, statistical techniques, and other elements of operations research.

445. COLLECTIVE BARGAINING.
(3-0) Cr. 3. F.W.
Prerequisite: 305.
Theory and practice of collective bargaining. Economic effects of collective bargaining. Problems in administration of contracts, including analysis of grievance arbitration and impact of public policy on labor relations.

447. INTRODUCTION TO AGRICULTURAL POLICY.
(3-0) Cr. 3. F.W. Alt. SSI, offered 1973.
Prerequisite: 242.
Introductory analysis of efficiency and income problems in American agriculture; description and appraisal of price-support programs, conservation programs, and programs to aid low-income families.

451. AGRICULTURAL LAW.
(3-0) Cr. 3. W.
The legal framework impinging upon decision making by farm firms, families, and individuals: liabilities, real and personal property, contracts, uniform commercial code, organization of farm firms, inter-generation property transfers, water law, fence law, federal and state regulatory powers, and insurance.

452. AGRICULTURAL TAXATION.
(3-0) Cr. 3. S.
Prerequisite: 451.
Income tax management, real and personal property taxes, estate and inheritance taxes, excise taxes, sales and use taxes imposed upon the farm family and firm. Emphasis on use of available source materials.

455. INTERNATIONAL ECONOMICS.
(3-0) Cr. 3. F.W.S.SSI.
Prerequisite: 242.
Principles of international trade, exchange rates, and balance of payments adjustments. Commercial and foreign investment policies. Foreign trade and American agriculture and industry.

456. INTERNATIONAL FINANCE.
(3-0) Cr. 3. W.
Prerequisite: 455.
Methods of financing international trade. The foreign exchange and the gold standard. International financial institutions, short- and long-term capital movements, and problems of international liquidity.

461, 462. URBAN-REGIONAL ECONOMICS.
(3-0) Cr. 3 each. 461: S.; 462: F.
Prerequisite: 242.
461: Theories of urban development; city typology and measurement; land-use analysis; trade and commuting patterns; urban economic interdependence; social investment in metropolitan communities. 462: Regional growth and efficiency; the locational determinants of firms and households; the regional economic base; resource development; economic planning in the city-region.

465. ECONOMICS OF EDUCATIONAL SYSTEMS.
(3-0) Cr. 3. W.
Prerequisite: 242, or permission of instructor.
Economic problems of public education, such as resources within school systems; economic analysis of resources available to schools and school systems; economic aspects of human resource development pertinent to education; interrelationships among an area's school system, its population and its resource base.

466. RETAILING.
(3-0) Cr. 3. S.
Prerequisite: 242.
Economic nature of retailing; retail market structure; store organization; merchandising and pricing policies; retail control.

490. SPECIAL PROBLEMS.
Cr. 1 to 5 each time taken. F.W.S.
Prerequisite: 242.
A. Agricultural Economics.
B. Economics.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

501, 502. INTERMEDIATE MICROECONOMIC ANALYSIS.
(3-0) Cr. 3 each. 501: F.W.SSI; 502: W.S.SSII.
Prerequisite: 308. Fletcher, Staff.
Economic theory and methodology; theory of consumer behavior and demand; production functions, costs, and firm behavior; equilibrium of consumers, firms, and industries; general equilibrium, economic efficiency, and welfare; behavior of firms in nonperfect competition and optimality of resource allocation; functional income distribution and the behavior of income shares.

503. INTERMEDIATE MACROECONOMIC ANALYSIS.
(3-0) Cr. 3. F.S.SSI.
Prerequisite: 409. Brady, Starleaf.
Determinants of the level of national income and employment; measurement, analysis, and control of aggregate economic activity. Examination of the postulates and policy implications of the classical, neoclassical, Keynesian, and neo-Keynesian models.

504, 505. QUANTITATIVE METHODS IN ECONOMIC ANALYSIS.
(0-3) Cr. 1 each. 504: F; 505: W.
Prerequisite: Graduate standing and permission of instructor.
Selected applications of mathematical and other quantitative techniques in economic analysis; economic application of selected concepts in finite mathematics, calculus, difference-differential equations, and elementary matrices.

510. NATURAL RESOURCE USE AND CONSERVATION.
(3-0) Cr. 3. W.SS.
Prerequisite: 308 or 434. Harl, Thomas, Timmons.
Natural resource classes and economic limits of investment and disinvestment in water, soil, forests, minerals, and air. Cost benefit analysis. Meaning of conservation. Multiple purpose uses. Economic principles applied to natural resources; their use and development. Appraisal of public interest and public controls, programs, and policies.

512. AGRARIAN REFORM AND ECONOMIC DEVELOPMENT.
(3-0) Cr. 3. S.
Prerequisite: 307 or 434. Timmons.
Meaning of economic development, underdevelopment, overpopulation, agrarian structures as obstacles to economic development. Improving agrarian structures through national, regional, and United Nations actions. Comparative structural change in countries.

515. INDUSTRIAL STRUCTURES AND COMPETITION.
(3-0) Cr. 3. F.
Prerequisite: 502. Fletcher, Harl, Merrill.
Business concentration in the American economy; structures and competitive practices of particular industries; mergers, vertical and horizontal integration; measurement and evaluation of competition and monopoly; economic problems of public control of competition.

516. ECONOMIC ASPECTS OF ANTITRUST AND TRADE REGULATION.
(3-0) Cr. 3. W.
Prerequisite: 515. Harl.
Analysis of the legal manifestations of national economic antitrust and trade regulation policy; rationale for public intervention in industrial organization and price output policy; exemptions from antitrust law; price control; market divisions and agreements not to compete; refusals to deal; monopoly; merger; resale price maintenance; discrimination in distribution; unfair trade practices; remedies under antitrust law; effectiveness of antitrust policy.

531. AGRICULTURAL MARKET ORGANIZATION AND BUSINESS BEHAVIOR.
(3-0) Cr. 3. F.
Prerequisite: 501. Fletcher.
Critical review of the theory of industry organization and firm behavior; analysis of the structures and competitive processes in agricultural product and factor markets; evaluation of economic performance under alternative normative criteria; legal restraints and marketing control programs.

532. QUANTITATIVE METHODS IN AGRICULTURAL MARKETING RESEARCH.
(3-0) Cr. 3. W.
Prerequisite: 501, credit or classification in Stat. 402. Ladd.
Examination of models and theories from economics and other social sciences relevant to marketing and forecasting problems; use of these models and theories for hypothesis formulation; selection and use of quantitative techniques.

533. RESEARCH DESIGN IN AGRICULTURAL MARKETING.
(3-0) Cr. 3. S.
Prerequisite: 501. Doak, Scott.
Current problems in agricultural markets and marketing; integration of theory, models, techniques and data in problem formulation; role of information in decision processes; research objectives, organization and financing—state, federal and industry; dissemination and application of research findings.

535. ECONOMIC DEVELOPMENT AND TRANSFORMATION OF AGRICULTURE.
(3-0) Cr. 3. Alt. W, offered 1972.
Prerequisite: 501. Heady.
Relation of economic growth to factor prices and the technological and firm structure; firm behavior and aggregate response in product supply and factor demand; developmental needs for transformation of agriculture and resource mobility; supply and resource problems under different stages of development; policy needs for alternative problems in development.

536. BUSINESS FLUCTUATIONS.
(3-0) Cr. 3. Alt. S, offered 1973.
Prerequisite: 409 or 503. Brady, Starleaf.
Dynamic theories of fluctuations in aggregate demand and aggregate economic activity.

537. LINEAR ECONOMIC MODELS.
(3-0) Cr. 3. F.
Prerequisite: 307, Math. 104. Ladd.
Selected applications of mathematics to economic problems; includes game theory, linear programming, and input-output analysis.

538. ECONOMETRIC STATISTICS.
(Stat. 538) See Statistics.

539. OPERATIONS RESEARCH.
(Stat. 539) See Statistics.

540. OPERATIONS RESEARCH METHODS AND ECONOMIC ANALYSIS.
(Stat. 540) See Statistics.

541. AGRICULTURE IN THE WORLD ECONOMY.
(3-0) Cr. 3. SSII.
Prerequisite: 242. Kaldor.
International comparison of development, adaptation, instability, and income problems in agriculture; world agricultural specialization and trade; policies of food importing and exporting nations and role of national and international agencies in agricultural development.

544. THEORY OF PUBLIC GOODS AND EXTERNALITY.
(3-0) Cr. 3. F.
Prerequisite: 501. Davis, Meyer.
Public goods, externality and social choice, public choice.

545. ECONOMICS OF TAXATION.
(3-0) Cr. 3. W.
Prerequisite: 503. Davis, Meyer.
Taxation, shifting and incidence, public debt, fiscal federalism.

548. QUANTITATIVE AGRICULTURAL PRICE ANALYSIS.
(3-0) Cr. 3. S.
Prerequisite: 307. Doak, Scott.
Measurement of supply and demand for agricultural products. Integration of government reports into outlook information for planning purposes by agricultural producers and marketing firms. Collection and analysis of price and quantity information.

551. MONETARY THEORY.
(3-0) Cr. 3. F.
Prerequisite: 503. Christian, Luckett.
The monetary mechanism: Neoquantity theory, neo-Keynesian monetary theory and the portfolio approach, microeconomic aspects of monetary theory, including monetary determinants of cost of capital. Rate of interest, expectations and lag in effect of monetary policy. Money supply theory.

552. ADVANCED MONEY AND BANKING.
(3-0) Cr. 3. W.
Prerequisite: 503. Christian, Luckett.
Theory and structure of commercial banking, the money and capital markets, financial intermediaries, and the Treasury with respect to central banking and monetary policy.

555. ADVANCED INTERNATIONAL ECONOMICS.
(3-0) Cr. 3. W.
Prerequisite: 307. Cheng, Thorbecke.
Modern theory of international pricing and allocation; foreign trade multiplier and international monetary equilibrium; problems of international economic stability; multilateral trade and economic development.

556. REGIONAL ECONOMICS.
(3-0) Cr. 3. Alt. W, offered 1972.
Prerequisite: 502. Prescott.
Theories of regional growth. Characteristics of viable economic regions. Spatial-economic models of urban and resource development.

557. ADVANCED INTERNATIONAL FINANCE.
(3-0) Cr. 3. S.
Prerequisite: 409; 503 and 555 recommended. Cheng.
Theory of foreign exchange, mechanism of adjustments in the balance of payments, exchange speculation and the forward exchange market, selected topics in international monetary policy.

561. AGRICULTURAL RESOURCE AND INCOME PROBLEMS.
(3-0) Cr. 3. F.
Prerequisite: 308. Kaldor.
Analysis of adjustment, instability, and income problems and their interrelationships; forces of agricultural disequilibrium, adaptability of the farm industry; sources of short-run price and income instability; farm family income problems related to structural imbalance and inadequate resources.

562. AGRICULTURAL PRICE AND INCOME POLICY.
(3-0) Cr. 3. W.
Prerequisite: 561. Ball, Kaldor.
Short- and long-run objectives of farm price and income policy; analysis and appraisal of agricultural price and income programs.

563. CONTEMPORARY ISSUES IN AGRICULTURAL POLICY.
(Pol.S. 563) (3-0) Cr. 3. S.
Prerequisite: 447, Pol.S. 473 recommended. Hadwiger, Kaldor, Talbot.
Politico-economic analysis of current agricultural policy issues. A major issue selected for analysis in depth. Underlying value judgments and empirical relationships identified and analyzed. Political acceptability of alternative solutions appraised.

565. ECONOMICS OF LOCATION.
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: 501. Faden.
Location of plants, industries, and residences. Commuting, migration, and commodity-flow patterns. Influence and design of the transportation-communication network. Influence of climate and resource distribution. Causes of agglomeration.

566. URBAN ECONOMICS.
(3-0) Cr 3. Alt. S, offered 1973.
Prerequisite: 501. Faden, Prescott.
History of world urban development; economic foundations of the city, agglomerating forces, linkage; theories of city growth—ring theories, sectoral theories, multiple nucleation; city system and urban hierarchies, coresuburban, hinterland relations and size distributions; commuting patterns, land-use patterns, CBD functions; metropolitan problems, transportation, housing, congestion, and neighborhood effects.

570, 571. ECONOMIC DEVELOPMENT AND GROWTH.
(3-0) Cr. 3 each. 570: F; 571: W.
Prerequisite: 570: 502; 571: 570. Sengupta, Thorbecke, Van de Wetering.
570: Determinants of economic development, development planning models, and conflicts between development objectives. 571: Applications of economic development theory to concrete situations at the national, sectoral, and regional levels. Empirical case studies. Choice of technique in development.

573, 574. APPLIED ECONOMETRIC MODELS.
(3-0) Cr. 3 each. 573: W; 574: S.
Prerequisite: 573: 538; 574: 573. Stephenson and staff.
Selected applications of econometric techniques to economic models.

576. REGIONAL ECONOMIC PLANNING.
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: 307. Prescott, Van de Wetering.
Regional economic aspects of resource management; role of economic information in physical planning. Problems of public policy for control and use of natural and human resources in regional development. Applications of systems analysis to public planning in river basins and metropolitan regions.

590. SPECIAL TOPICS.
Cr. 1 to 5 each time taken.
A. Agricultural Economics.
B. Economics. Topics will be chosen from, but not limited to: (1) Economic analysis of rural-urban educational systems. (2) Information economics and systems analysis.

591. COMPARATIVE TRADE UNIONISM.
(3-0) Cr. 3. Alt. S, offered 1973.
Prerequisite: 502. Davey.
Analytical survey of contemporary trade unionism in the United States and selected Western European countries, with special emphasis on the transferability of objectives, procedure, and techniques to free trade union movements in newly emerging nations and economically underdeveloped areas.

592. ECONOMICS OF THE LABOR MARKET.
(3-0) Cr. 3. Alt. F, offered 1971.
Prerequisite: 502. Jakubauskas.
Advanced research and analysis of current problems of manpower development and utilization, unemployment and underemployment, and changes in the industrial and occupational composition of the labor force.

593. WAGES AND THEORIES OF WAGE DETERMINATION.
(3-0) Cr. 3. Alt. F, offered 1972.
Prerequisite: 502. Palomba.
Macro and micro wage theory, the economic and institutional forces determining wage levels and differentials, theory of bargaining power in wage determination.

594. COMPARATIVE MANPOWER DEVELOPMENT.
(3-0) Cr. 3. Alt. W, offered 1973.
Prerequisite: 502. Jakubauskas.
Strategies for the development of human re-

sources in developing economies; manpower development planning; the relationship of economic development to education, training, and manpower utilization.

595. **LAW OF LABOR RELATIONS.**
(3-0) Cr. 3. Alt. W, offered 1972.
Prerequisite: 305. Davey.
Federal and state legislation affecting the collective bargaining process, including analysis of selected court decisions. Role of government in adjustment of labor disputes. Legal aspects of labor arbitration.

596. **ECONOMICS OF COLLECTIVE BARGAINING.**
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: 502. Davey, Palomba.
Economic effects of collective bargaining at both the microeconomic and macroeconomic levels. Union wage policy and employment effects. Wage-price-profit-productivity relationship. Economic aspects of adjustment to technological change through collective bargaining.

COURSES FOR GRADUATE STUDENTS, major or minor

601, 602, 603. **ADVANCED ECONOMIC THEORY.**
(3-0) Cr. 3 each. Yr.
Prerequisite: 601: 503; 602: 601; 603: 602. Brady, Starleaf, Stephenson, staff.
601: Capital theory: Productivity of capital, intertemporal resource allocation and investment criteria, production functions and technical change, theories of investment. Walrasian general equilibrium theory. 602: Axiomatic approach to general equilibrium theory. Linear programming model of general equilibrium. Welfare economics: Pareto optimality and the various compensation principles, social welfare function. 603: Post-Keynesian developments of the consumption function. Real balance effect. Monetary theories of interest. Dynamic models.

605, 606. **HISTORY OF ECONOMIC THOUGHT.**
(3-0) Cr. 3 each. 605: F; 606: S.
Prerequisite: 502, 503. Luckett.
Principal figures in the development of economic ideas; contribution of each period of economic thought. 605: The Mercantilists to the Classical School, inclusive. 606: Critics of the Classical School to J.M. Keynes.

614, 615. **ADVANCED THEORETICAL ANALYSIS.**
(3-0) Cr. 3 each. 614: F; 615: W.
Prerequisite: 614: 502, Math. 204 or 307, 409; 615: 614. Faden, Van Moeseke.
614: The axiomatic method. Local and global equilibrium of the consumer. Slutsky equation. Preference preorders; (continuous) numerical representation and derivation from the revealed-preference axioms. Equilibrium of the firm. Nonlinear programming; general duality and distribution theorems. Stochastic formulations. 615: Existence and efficiency propositions of the general competitive equilibrium. Abstract economies. The Nash theorems. Applications to duopoly and oligopoly. General minimax theorems. Edgeworth market with continuum of traders. Effective coalitions and core allocations. Specialization of the efficiency theorems to activity analysis; price-guided allocations.

630. **ADVANCED NATURAL RESOURCE ECONOMICS.**
(3-0) Cr. 3. F.
Prerequisite: 308 or 434. Harl, Thomas, Timmons.
Natural resource supply and demand. Legal, socio-economic, and technological aspects. Externalities. Multiple purpose uses. Cost-benefit analysis. Tenure systems. Private and public interests in use and development. Policy alternatives.

634. **LAND VALUATION.**
(3-0) Cr. 3. S.
Prerequisite: 307. Murray.
Factors determining land value; fluctuation in land prices; critical evaluation of appraisal methods.

635. **FARM CREDIT THEORY.**
(3-0) Cr. 3. W.
Prerequisite: 307; 308 recommended. Murray.
Farm credit policies and methods of extending credit. Organization and operation of lending agencies, private and governmental. Evaluation of alternative agricultural credit systems.

638. **ADVANCED ECONOMETRIC STATISTICS.**
(Stat. 638) See Statistics.

641. **ECONOMICS OF AGRICULTURAL PRODUCTION.**
(3-0) Cr. 3. F.
Prerequisite: 501. Heady.
Production principles applied to use of land, labor, and capital; static and dynamic firm theory; farm size; resource and product combinations; production location; timing of production and conservation; cost structure; leases and asset control; uncertainty and expectations.

642. **RESOURCE EFFICIENCY AND ALLOCATION IN AGRICULTURE.**
(3-0) Cr. 3. W.
Prerequisite: 641. Heady.
Efficiency criteria; inter-industry productivity comparisons; technological change; resource mobility; firm-household interrelationships; returns to farm and society; causes of and means for eliminating production inefficiency.

645. **MATHEMATICAL METHODS IN ECONOMIC THEORY.**
(3-0) Cr. 3. S.
Prerequisite: 615. Van Moeseke, Sengupta.
Dynamic programming. The Pontryagin maximum principle and optimal controls: Existence, local stability, and global stability theorems of Walrasian markets under alternative assumptions. Malinvaud and Allais efficiency of intertemporal allocations. Balanced growth and growth at a maximal rate; existence and turnpike theorems.

646. **TIME SERIES.**
(Stat. 646) See Statistics.

660. **WELFARE ECONOMICS.**
(3-0) Cr. 3. S.
Prerequisite: 602. Holdren.
A rigorous re-examination of efficiency, Pareto optimality and compensation principles. Set theoretic and mathematical programming approaches in welfare. Axiomatic treatments of social choice. Bergsonian social and economic welfare functions. Problems at the frontier of welfare economics.

670. **RESOURCE ALLOCATION IN FORESTRY.**
(For. 670) See Forestry.

672. CAPITAL AND GROWTH.
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: 570, 603. Sengupta.
Theories of capital accumulation and multisector models of economic growth; optimum and efficient growth; applications to planning and resource allocation models; stochastic process applications.

690. SEMINAR.
Cr. 1 to 3 each time taken. F,W,S.
Prerequisite: Six credits of graduate work in chosen field.
Current topics in economic theory and applied economics. Offerings each quarter will be selected from the following list:
A. Industrial Organization.
B. International Economics.
C. Economic Development and Policy.
D. Monetary Economics.
E. Public Finance.
F. Urban-regional Economics.
G. Agricultural Marketing and Price Analysis.

696A, 696B, 696C. THEORY OF QUANTITATIVE ECONOMIC POLICY.
(3-0) Cr. 3 each. Yr.
Prerequisite: Permission of instructor. Sengupta, Thorbecke, Van de Wetering.
696A: Formulation and specification of policy models applied to problems of economic stabilization and economic development, mainly at the national level. Economic forecasting and reliability analysis for economic policy models. 696B: Economic policy models and the theory of optimal control. Specification and computation of optimum policy in dynamic economic models. Certainty equivalence theorem and decision rules. Continuous and discrete versions of the maximum principle and their economic applications to growth, stabilization, and other problems. 696C: Economic policy models at the sectoral level. Sectoral planning applied to agriculture, transportation, education, and other sectors. Changes in technology and their effects on sectoral objectives.

699. RESEARCH.
A. Agricultural Economics.
B. Economics.

EDUCATION

Ray J. Bryan, Ph.D., Professor in Charge, Professional Studies

The Graduate Faculty

Members: J.A. Bath, R.J. Bryan, C.E. Bundy, D.C. Charles, H.R. Crawford, H.E. Dilts, A.M. Gowan, G.A. Kizer, E.L. Kohlmann, V.S. Lagomarcino, R.P. Manatt

Associate Members: J.R. Beard, I. Beavers, N.L. Boyles, M.D. Brown, R.J. Canute, J.K. Dissinger, R.A. Engle, D.E. Harding, W.E. Hart, T.A. Hoerner, G.E. Holmes, G.C. Hopper, T.G. Howe, A.A. Kahler, P. Keith, C.W. Keller, C.R. Kniker, R.L. Lawrence, E.D. Mallam, E.M. Merkley, P.G. Miller, A.J. Netusil, D.D. Pellegreno, R.L. Redick, P.T. Rosewell, C.A. Sandeen, W.C. Schloerke, L.G. Smith, R.A. Thomas, V.F. Thomas, R.P. Volker

The College of Education offers work for the degrees Master of Science, Master of Education, and Doctor of Philosophy in education with major work in education or in industrial education, and minor work to students taking major work in other departments. Within the education major, a student may specialize in adult education, educational administration, higher education, evaluation, extension education, guidance and counseling, and philosophy of education. For information concerning the industrial education major, see *Industrial Education.*

Prerequisite to major graduate work in education is preparation substantially equivalent to the completion of one of the undergraduate curricula in education offered at Iowa State University and adequate proof that the student ranks above average in scholastic ability and promise of professional competency.

There is no language requirement for the degrees Master of Science or Master of Education. A satisfactory reading knowledge of two languages selected from French, German, Russian, or Spanish is required of doctoral candidates. At the discretion of the student's advisory committee, the foreign language requirement may be met by: (1) demonstrating a satisfactory reading knowledge of two of the languages named; (2) demonstrating a significantly higher degree of competence in one of the named languages; (3) substituting two years of undergraduate study in the language with a B average for one of the above languages; or (4) substituting nine quarter credits of graduate work in addition to the minimum Ph.D. requirements in approved areas for one language or 18 credits for two languages. Students whose native language is not English may substitute competence in English for one of the languages.

Other graduate programs related to education may be planned for students on the basis of previous education and experience as well as future plans and needs. Students should refer to the *Index* and to graduate level course offerings for their area of interest.

COURSES FOR GRADUATE STUDENTS, minor only

426. **PRINCIPLES OF SECONDARY EDUCATION.**
(3-0) Cr. 3. F.W.S.SSI.
Prerequisite: 305 or equivalent.
Problems of teacher relationships; pupil management and guidance; the curriculum; extra-curricular activities; trends in education; secondary school population; community school; evaluation of pupil progress; codes of professional ethics.

468. **EXTENSION EDUCATION.**
(3-0) Cr. 3. F.
Prerequisite: Permission of instructor.
History and philosophy of university extension education; objectives, organization, and programs of university extension. Principles and procedures of instruction and evaluation in extension education.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

501. **SOURCES, SELECTION, AND PREPARATION OF EDUCATIONAL MEDIA.**
(2-2) Cr. 3. F.SSI.
Prerequisite: 305B. Volker.
Organization of educational media centers. Sources and selection of software and hardware. Analysis of current research in effectiveness of teaching and learning through media. Projection of a variety of teaching materials.

502. **PRODUCTION OF VISUAL MEDIA.**
(2-2) Cr. 3. W.
Prerequisite: 501. Volker.
Designing, scripting, and producing film loops, photo essays, and video tapes. Implementation of research in development of effective projected materials.

503. **DESIGNING INSTRUCTIONAL SYSTEMS.**
(2-2) Cr. 3. S.
Prerequisite: 502. Volker.
Designing, scripting, and producing multi-media presentations for individual or group instruction. Research methods of evaluating multi-media instruction.

515. **EVALUATION OF EDUCATIONAL OUTCOMES.**
(3-0) Cr. 3. W.SS.
Prerequisite: Fifteen credits in education. Howe.
Methods of evaluating educational outcomes, types of tests and their construction, use and interpretation of educational materials in teaching.

517. **SUPERVISION OF STUDENT TEACHERS AND OTHER PREPROFESSIONAL LABORATORY EXPERIENCES.**
(3-0) Cr. 3. SS.
Prerequisite: Permission of instructor. Schloerke.
Designed for elementary and secondary school teachers. Emphasis is placed on the cooperating teacher's role relative to student teachers and teaching interns. Consideration is given to such topics as the orientation and guidance of future teachers, practical value of observation, cooperating teacher-student teacher planning, and continuous evaluation throughout the program.

520. **TEACHING STRATEGIES AND ELEMENTARY SCHOOL ORGANIZATION.**
(5-0) Cr. 5. F.S.SSI.
Prerequisite: El.Ed. 344, Psych. 333. Hohl.
The role of the school organization in the development and the utilization of teaching strategies and the effect of various strategies on learning.

522. **PRINCIPLES OF CORRECTIVE READING.**
(3-0) Cr. 3. W.S.SSI.
Prerequisite: 520. Merkley.
Identification, symptoms, causes, assessment, and correction of reading problems within the elementary classroom instructional program.

530. **PRINCIPLES AND PRACTICES OF GUIDANCE.**
(3-0) Cr. 3. W.SS.
Prerequisite: Fifteen credits in education and psychology, including Educ. 426 and Psych. 333. Bryan, Hopper, Pellegreno.
Principles and practices in the guidance services; individual inventory, informational services, counseling, placement, follow-up, assisting school staff, and coordination of school, home, and community efforts.

531. **ANALYSIS OF THE INDIVIDUAL.**
(2 or 3-0) Cr. 2 or 3. F.W.SS.
Prerequisite: 530, Psych. 440. Canute, Hopper.
Collection, organization, and interpretation of data pertinent to the study of pupils in relation to problems of educational and vocational planning and personal adjustment. Includes techniques for identifying the utilizing sources of information, and for collecting, analyzing, recording, and maintaining data about individual pupils.

532. **GUIDANCE SERVICES IN THE ELEMENTARY SCHOOL.**
(3-0) Cr. 3. F.S.SS.
Prerequisite: Educ. 530. Pellegreno.
Overview of current practices in guidance at the elementary school level; guidance services, roles of personnel involved, and the articulation of the elementary and secondary school guidance programs.

533A, 533B, 533C. **COUNSELING STUDENTS.**
(3-0) Cr. 3 each. 533A: F.S.SS; 533B: W.SS; 533C: W.SS.
Prerequisite: 533A: 530; 533B: 533A; 533C: 532, 533A. Hopper, McMillen, Miller, Pellegreno.
533A: Introduction to School Counseling. Consideration of major approaches to counseling secondary and elementary school students. 533B: Techniques of Counseling Secondary School Students. Interviewing with students, role playing, and observation of counseling. 533C: Techniques of Counseling Elementary School Students. Use of play media in counseling emphasized. Interviewing and observations of counseling.

534. **ADMINISTRATION OF THE GUIDANCE SERVICES.**
(2 or 3-0) Cr. 2 or 3. S.SS.
Prerequisite: 530. Bryan, Hopper, McMillen, Pellegreno.
Administrative principles and practices in organizing and implementing the guidance services.

535. **GROUP PROCEDURES IN GUIDANCE.**
(3-0) Cr. 3. F.S.SS.
Prerequisite: Permission of instructor. Hopper, Pellegreno.
Methods for organizing, maintaining, conducting, and evaluating group counseling sessions.

536. **ADULT EDUCATION.**
(1 or 2-3) Cr. 2 or 3. F.
Prerequisite: Fifteen credits in education. Holmes.
Philosophy and need for continuing education in a democratic society. Survey of current trends with emphasis upon adult education contributions of many agencies in the community. Focus upon the adult as a participant in continuing education.

537. METHODS OF TEACHING ADULTS.
(1 or 2-3) Cr. 2 or 3. SSII.
Prerequisite: Fifteen credits in education or permission of instructor. Holmes.
Principles and practices in directing adult learning-experience activities. Techniques for leading adult groups in both formal and informal situations. Study and evaluation of various methods including creative techniques in group planning and decision making.

541. INTRODUCTION TO EDUCATION ADMINISTRATION.
(2 to 4-0) Cr. 2 to 4. F.SSI.
Prerequisite: 426, Psych. 333. Engel.
Philosophy and purposes of education in a democratic society. Basic principles of school administration. Analysis of the nature and function of units of education at local, intermediate, and state levels; principles and procedures for their reorganization.

542. THE COMMUNITY PROGRAM OF SECONDARY EDUCATION.
(2 or 3-0) Cr. 2 or 3. SSI.
Prerequisite: 426. Dilts.
The academic and vocational programs of community high schools; extra-class activities; education programs for post-high school youth and adults; local community resources as curriculum content; curriculum revision.

543. THE ADMINISTRATION OF SCHOOL PERSONNEL I.
(2 or 3-0) Cr. 2 or 3. W.SSI.
Prerequisite: Fifteen credits in education. Engel.
Selection and organization of the teaching staff; personnel policies; stimulation of professional growth; management of nonprofessional employees. Nature of leadership.

544. FACILITIES IN HIGHER EDUCATION.
(2 or 3-0) Cr. 2 or 3. S.SSI.
Prerequisite: 549. Hart.
Educational specifications for community college including socioeconomics, transportation and traffic systems, and population centers in geographic areas. The planning team. Curriculum, enrollment projections, and programming of required space needs.

545. THE COMMUNITY PROGRAM OF ELEMENTARY EDUCATION.
(2 to 4-0) Cr. 2 to 4. SSI.
Prerequisite: Fifteen credits in education. Hohl.
Problems of organization and administration of the elementary school program in relation to current theories and practices. Review of state courses of study; areas-of-living education; the fine arts; elementary school extra-class activities; community resources.

546. SCHOOL BUSINESS MANAGEMENT.
(3-0) Cr. 3. W.SSI.
Prerequisite: 541. Engel, Hart, Manatt.
Fiscal administration of local school systems; budgeting; financial accounting; auditing school accounts and other aspects of school business management, including insurance, transportation, buildings and grounds, and planning and construction.

547A, 547B. SUPERVISION OF INSTRUCTION.
(3-0) Cr. 3 each. 547A: S.SS; 547B: F.SS.
Prerequisite: Fifteen credits in education. 547A: Hohl. 547B: Engel, Manatt.
547A: Improvement of teaching and learning in elementary schools. Evaluation of teaching effectiveness. Techniques of team teaching, individualized instruction, and continuous learning progress. 547B: Purposes of educational supervision; review of modern secondary school methods of teaching; common techniques of supervision; evaluation of teaching and learning.

548. EDUCATIONAL POLICY MAKING AND INTERPRETATION.
(3-0) Cr. 3. W.SSI.
Prerequisite: 541. Engel.
Historical and legal bases of educational government in the United States; current issues in educational policy making at the local, state, and national levels; problems of implementing policy and interpreting educational programs to the community.

549. PLANNING PUBLIC SCHOOL FACILITIES.
(3-0) Cr. 3. SS.
Prerequisite: 541. Hart.
Assessment of need for new buildings; selection and acquisition of site; selection of architect; educational specifications; construction of new buildings.

551. OCCUPATIONAL INFORMATION.
(3-0) Cr. 3. F.W.SS.
Prerequisite: Fifteen credits in education and psychology. Bryan, Hopper, Jones.
Methods and techniques of occupational analysis, description and presentation of analysis, description and presentation of occupational information to high school pupils. Growth and development of important occupations, statistics, and trends. For teachers and counselors. Field trips to industrial plants.

552A, 552B, 553. EDUCATIONAL STATISTICS.
(3-1) Cr. 3 each. F.W.S.SS.
Prerequisite: 552A: Fifteen credits in education, five credits in mathematics; 552B: Fifteen credits in education; 553: 552A. Howe, Netusil.
Statistical concepts and procedures for analyzing educational data. Designed for teachers, school administrators, or educational research workers. Concepts of descriptive and inferential statistics are stressed.

555. ORGANIZATION AND ADMINISTRATION OF JUNIOR HIGH-MIDDLE SCHOOL.
(2 or 3-0) Cr. 2 or 3. W.SS.
Prerequisite: 426. Manatt.
Current practices and trends in the organization of the junior high school, including underlying psychological and educational theory. Responsibilities of the junior high school principal for scheduling, selection, and leadership of teaching personnel; records and reports; extracurricular activities; discipline; business administration.

556. ADMINISTRATION OF AREA VOCATIONAL-TECHNICAL SCHOOLS AND COMMUNITY COLLEGES.
(3-0) Cr. 3. W.SSI.
Prerequisite: 541, 543, 548 or equivalent. Brown.
Scope, administration, organization, and evaluation of programs for area vocational-technical schools and community colleges.

560. HIGHER EDUCATION IN UNITED STATES.
(3-0) Cr. 3. F.SSI. Brown.
A survey course including historical development, institutional governance, multiplication and diversity of colleges, administrative structure, organization, trends, and issues. A prerequisite for other courses in higher education.

561. METHODS OF COLLEGE TEACHING.
(2 or 3-0) Cr. 2 or 3. F.S.SSI.
Prerequisite: Fifteen graduate credits. Kizer.
Basic educational theory and methods; abilities essential to effective teaching.

562. CURRICULUM AND INSTRUCTION IN HIGHER EDUCATION.
(3-0) Cr. 3. W.SSII.
Prerequisite: Fifteen graduate credits. Brown.
Issues, trends, and principles in curriculum development; experimental programs; interrelationship of general and specialized education; liberal education; professional education.

563. COLLEGE PERSONNEL POLICIES AND PRACTICES.
(3-0) Cr. 3. S.SSII.
Prerequisite: 560. Brown.
A profile of the college teacher, his special problems, interests, and goals; an examination of personnel problems in colleges and universities, including community colleges. In-service development, salaries, fringe benefits, promotion, tenure, retirement, and recruitment will also be discussed.

564. STUDENT PERSONNEL SERVICES IN HIGHER EDUCATION.
(3-0) Cr. 3. W.SS.
An introduction to the field of student personnel work, with a consideration of student activities, counseling services, financial aid, admissions, student conduct, and residential programs. Includes study in community college programs.

565. ORGANIZATION AND ADMINISTRATION OF STUDENT PERSONNEL SERVICES IN HIGHER EDUCATION.
(3-0) Cr. 3. S.SS.
Organizational structures considered; role and functions of members of student personnel staff; policies and decision making for student personnel services emphasized.

570. PROGRAM PLANNING IN ADULT EDUCATION.
(3-0) Cr. 3. F.
Prerequisite: 536. Beavers.
Principles and procedures in identifying and appraising program opportunities in adult education. Emphasis will be upon involvement of participants and integration of information in selecting program objectives.

575. FUNDAMENTALS OF SCHOOL LAW.
(3-0) Cr. 3. S.SS.
Prerequisite: 541, 543. Engel, Manatt.
Fundamentals and principles of law as related to the state and education, reorganization, liability, board procedures, pupil regulation, conditions of employment.

576A, 576B. DUTIES OF SCHOOL PRINCIPALS.
(2 or 3-0) Cr. 2 or 3 each. 576A: F.SS; 576B: W.SS.
Prerequisite: 541. 576A: Hohl; 576B: Engel, Manatt.
576A: Elementary school organization for teaching and learning. Time allotments, staff utilization, team teaching, and student control. Executive and planning functions of the elementary school principal. Historical perspectives of this management profession. 576B: Secondary school organization, schedule making, management of pupil organizations, evaluation of pupil growth. Evaluation of the total program, staff utilization, and leadership.

584A, 584B. HISTORY OF EDUCATION.
(2 or 3-0) Cr. 3. 584A: W; 584B: SSII.
Prerequisite: Fifteen credits of graduate work. Kizer, Kniker, Smith.
584A: History of European Education. Educational practices and institutions in ancient Greece and Rome; medieval educational patterns; rise of universities; impact of the Renaissance, Reformation, and Counter-Reformation; development of national systems of education with special attention to England, France, and the German area. 584B: History of American Education. European heritage; colonial institutions and practices; influences from Enlightenment; Jacksonian democracy and the rise of tax support and state supervision; response to industrialization; educational reform movements; twentieth century developments and trends.

585. COMPARATIVE EDUCATION.
(3-0) Cr. 3. SSI.
Prerequisite: Fifteen credits of graduate work. Smith.
Development, principles, and uses of comparative education; comparative analysis of selected educational systems, practices, objectives, and problems; specific countries treated will vary from time to time.

590. SPECIAL TOPICS.
Cr. 1 to 5.
Prerequisite: Fifteen credits in education.
B. Adult Education.
C. Secondary Education.
D. Vocational Educational Guidance.
E. Administration of Education.
F. Supervision of Education.
G. Techniques of Research in Education.
I. Elementary Education.
J. Science Education.
K. Classroom Utilization of Audiovisual Aids, Including Radio and Television.
L. Higher Education.
M. Extension Education.
N. Curriculum.
P. Philosophy, History of Comparative and International Education.
W. Administration and Supervision of Physical Education for Women.

591. SUPERVISED FIELD EXPERIENCE.
(0-3 to 9) Cr. 1 to 3. F.W.S.
Prerequisite: Fifteen credits graduate work in special area.
Supervised on-the-job field experience in special areas.
D. Secondary School Guidance.
E. School Administration.
F. Elementary School Guidance.
G. Community College Student Personnel Services.
J. Higher Education.

592. SUPERVISED PRACTICE IN COUNSELING.
(1-6 to 8) Cr. 3 or 4. F.W.S.SS.
Prerequisite: 592A: 533A, 533B or C, permission of instructor; 592B: Six credits of 592A and permission of instructor.
A. Counseling Practicum.
B. Supervision of Counseling Practicum.
Educ. 592B is primarily a doctoral level course and will be taken by students who plan to pursue counselor education careers. Because of the importance attached to the counseling practicum in most counselor education institutions, skills in supervision of practicum are necessary for a doctoral student seeking employment.

593. WORKSHOP.
Cr. 1 to 5. SS.
Prerequisite: Fifteen credits in education.
B. Adult Education. Beavers, Holmes, Lawrence.
C. Secondary Education. Dilts, Manatt, Schloerke.
D. Vocational Educational Guidance. Bryan, Hopper, Pellegreno.
E. Administration of Education. Dilts, Engel, Hart, Holmes, Manatt.
F. Supervision. Manatt.
G. Research and Evaluation. Howe, Netusil.
I. Elementary Education. Beard, Merkley.
L. Higher Education. Brown.
N. Curriculum. Dilts.

596. CURRICULUM CONSTRUCTION.
(3-0) Cr. 3. W.SSI.
Prerequisite: Fifteen credits of graduate work in education. Dilts.
An analysis of curriculum theories and principles of curriculum construction. Survey of curriculum trends, promising practices, and sociocultural factors affecting the curriculum.

COURSES FOR GRADUATE STUDENTS, major or minor

601. PHILOSOPHY OF EDUCATION.
(3-0) Cr. 3. F.SSII.
Prerequisite: Fifteen credits of graduate work in education. Kizer.
Philosophical traditions of the ancient and medieval world. Traditions of the modern world. Analysis and classification of contemporary American educational theories and philosophies.

602. CURRENT EDUCATIONAL ISSUES.
(2 or 3-0) Cr. 2 or 3. W.
Prerequisite: Fifteen credits in graduate work in education. Kizer.
Selected educational issues, movements, or problems in contemporary American education.

603. PHILOSOPHICAL IDEAS IN AMERICAN EDUCATION.
(3-0) Cr. 3. S.
Prerequisite: 601. Kizer.
An intensive analysis and criticism of selected educational theories and issues. Synthesis and evaluation of their bearing on educational theory and practice.

615. SEMINAR.
(1 to 3-0) Cr. 1 to 3. F.W.S.
B. Adult Education.
C. Secondary Education.
D. Guidance.
E. Educational Administration.
F. Supervision.
G. Research and Evaluation.
I. Elementary Education.
L. Higher Education.
P. Philosophy, History, and Comparative Education.

624. RESEARCH METHODS IN EDUCATION.
(3-0) Cr. 3. S.SSI.
Prerequisite: Fifteen credits in education. Howe.
Adaptation of research techniques to problems in education. Primarily for students preparing to write theses.

641. ADMINISTRATIVE PROBLEMS.
(3-0) Cr. 3. F. Alt. SSI, offered 1972.
Prerequisite: 541, 543. Engel.
A case-study approach to problems in educational administration. Focuses on the development of competences for dealing with actual situations.

643. THE ADMINISTRATION OF SCHOOL PERSONNEL II.
(3-0) Cr. 3. S.
Prerequisite: 543. Engel.
An in-depth exploration of problems in the administration of school personnel in relation to current theories and practices. Topics will include collective negotiation, differentiated staffing, and personnel selection and maintenance.

644. EDUCATIONAL FINANCE.
(2-4) Cr. 2 to 4. S.
Prerequisite: 541. Hart.
Application of the principle of public finance to education; school revenues and expenditures as part of the fiscal problem of government at the local, state, and federal levels.

663. RESEARCH IN THE ANALYSIS OF TEACHING.
(3-0) Cr. 3. S.
Prerequisite: Nine credits of graduate work in education. Dilts, Schloerke.
Critical examination of various systems for studying and evaluating teaching; descriptive studies and conceptual systems of teaching; their nature and possible uses; major research attempts in assessing teaching effectiveness along with ensuing problems connected with such efforts.

664. COLLEGE ORGANIZATION AND ADMINISTRATION.
(3-0) Cr. 3. F.
Prerequisite: 560. Brown, Gowan.
Lectures and discussions relating to administrative organization and behavior: communications, leadership, distribution of power, institutional report writing, job analyses, legal bases, and institutional governance.

665. FINANCING HIGHER EDUCATION.
(3-0) Cr. 3. W.
Prerequisite: 560. Brown.
Lectures, discussions, and individual investigation relating to financial administration in colleges and universities. Budgeting, space utilization, administration of sponsored research, fund raising, investments, examination of theories on expenditures. Designed for persons aspiring to college administration.

678. ADMINISTRATIVE THEORY IN EDUCATION.
(3-0) Cr. 3. S.
Prerequisite: Master's degree, permission of instructor. Manatt.
The historical background of current thinking in administration and organization; theoretical approaches to administration; analysis of functions and processes of administration as they apply to education. For experienced administrators.

679. ADVANCED ADMINISTRATIVE THEORY IN EDUCATION.
(3-0) Cr. 3. S.
Prerequisite: 678. Manatt.
Critical evaluation of the major research in systems analysis, operations research and prediction models as they apply to the management of schools and colleges. Simulation by in-basket techniques and computer. Model building from isomorphisms selected from management strategies in business and industry.

680. THE TEACHING-LEARNING PROCESS IN ADULT EDUCATION.
(3-0) Cr. 3. S.
Prerequisite: 570. Lawrence.
Inquiry into psychological and sociological factors in adult behavior as they affect learning; special emphasis on differences between adults and youth as learners and their implications for adult teaching. The inductive approach to adult learning will be emphasized.

699. RESEARCH.
Cr. arr.
Prerequisite: Fifteen credits in education.

ELECTRICAL ENGINEERING

Warren B. Boast, Ph.D., Head of Department

The Graduate Faculty

Members: P.M. Anderson, W.B. Boast, R.G. Brown, N.R. Cholvin, M.S. Coover, A.A. Fouad, H.W. Hale, H.C. Hsieh, G.G. Koerber, A.N. Michel, E. Nasser, A.V. Pohm, R.E. Post, A.A. Read, R.M. Stewart, G.R. Town

Associate Members: J.P. Basart, P.R. Bond, D.W. Bowen, H.C. Brearley, W.H. Brockman, J.M. Brown, R.C. Camp, D.L. Carlson, L.B. Coady, C.S. Comstock, G.E. Fanslow, C.J. Hergett, R.E. Horton, E.C. Jones, M.H. Mericle, J.D. Musil, J.W. Nilsson, A.G. Potter, D.D. Robb, R.L. Samuels, T.M. Scott, D.C. Scouten, T.A. Smay, D.T. Stephenson, C.S. Swift, C.L. Townsend, C.J. Triska, R.M. Willett, R.J. Zingg

The department offers work for the degrees Master of Science, Master of Engineering, and Doctor of Philosophy with major in electrical engineering and minor work to students taking major work in other departments.

Minor work for electrical engineering majors is usually selected from mathematics, physics, chemistry, nuclear engineering, aerospace engineering, or the life sciences.

There is no foreign language requirement for the degrees Master of Science or Master of Engineering. The foreign language requirement for the degree Doctor of Philosophy consists of the completion, with grades of C or better, of one of the following foreign language sequences (or equivalent):

101, 102, 103 (French)
121, 122, 123 (Russian)
131, 132, 133 (German)
151, 152, 153 (Spanish)

The department also offers major work for the degree Master of Engineering at approved off-campus locations. A minimum of 12 credits for work taken in residence on the Iowa State University campus is required. Thesis requirements may differ from those for the Master of Science degree.

Electrical engineering is quite diverse, especially at the graduate level. Thus students can find considerable course offerings and research opportunities in biomedical engineering, circuit theory, computer technology, control and information systems, electric energy sources and conversion, electromagnetic wave propagation, electronic devices, electronic materials, and power systems engineering.

The normal prerequisite to major graduate work in electrical engineering is the completion of undergraduate work substantially equivalent to that required of engineering students at this university. Because of the diversification in the electrical engineering graduate program, however, it is possible for a student to qualify for graduate study in some of the areas enumerated above, even though his undergraduate or prior graduate training has been in a discipline other than electrical engineering. Supporting work, if required, will depend on the student's background and his area of research interest. A prospective student from a discipline other than a curriculum in electrical engineering is urged to submit, with his application for admission, a statement of his proposed area of graduate study.

Courses normally will be offered as stated in the course description. Where no specific time of offering is stated, the course may be offered during any quarter provided there is sufficient demand.

Instruction in biomedical engineering is provided jointly by the Colleges of Engineering and Veterinary Medicine. Laboratory facilities are available in the Biomedical Engineering Building. See *Biomedical Engineering* for requirements.

COURSES FOR GRADUATE STUDENTS, minor only

308, 309. ELECTRIC CIRCUIT ANALYSIS AND DESIGN I, II.
308: (4-0) Cr. 4. F.W; 309: (3-2) Cr. 4. W.S.
Prerequisite: 308: 206, credit or classification in Math. 322; 309: 308.
Laplace transforms in circuit theory. Fourier expansions. Matrices in circuit theory. Driving point and transfer functions. Bode diagrams. Properties and design of RC and LC networks. Impedance matching. Scattering parameters. Introduction to modern filter synthesis.

313. ELECTRIC AND MAGNETIC FIELD THEORY I.
(4-0) Cr. 4. F.S.
Prerequisite: Math. 213, Phys. 223.
Vector analysis, principles of electrostatic fields, energy and potential, capacitance, Laplace's equation and application to static and quasi-static problems, numerical solutions of Laplace's equation.

314. ELECTRIC AND MAGNETIC FIELD THEORY II.
(4-0) Cr. 4. F.W.
Prerequisite: 313.
Principles of magnetostatic fields, magnetic circuits, inductance, Faraday's Law, displacement current, Maxwell's equations, introduction to wave concepts and energy flow in transmission lines and electromagnetic waves.

317. ELECTROMECHANICAL DEVICES.
(3-2) Cr. 4. W.S.
Prerequisite: 308, 314, E.M. 345.
Fundamentals of electromechanical energy conversion with emphasis on the physical phenomena involved in the interaction between electromagnetic fields and the mechanical forces. Typical devices which are best explained through an application of both field concepts and circuit concepts are discussed.

351. ELECTRIC MACHINERY.
(3-2) Cr. 4. F.S.
Prerequisite: 317, credit or classification in 309.
Analysis of rotating electric machinery with emphasis on applications.

374, 375, 376. ELECTRONICS ENGINEERING.
(3-3) Cr. 4 each. 374: F.S; 375: F.W; 376: W.S.
Prerequisite: 374: 206, credit or classification in 232; 375: 374, credit or classification in 308; 376: 375, credit or classification in 309 and Phys. 302.
Introduction to transistor physical electronics. Linear, piecewise-linear and large-signal modeling of selected electronic devices. Analysis of electronic circuit topics such as biasing, amplification, application of circuit theorems, frequency characteristics, distortion, power dissipation, feedback effects, oscillation, switching.

404. INTRODUCTION TO LINEAR CONTROL SYSTEMS.
(3-0) Cr. 3. F.
Prerequisite: Math. 321.
Introduction to the representation and analysis of linear control systems in the frequency and time domains.

410. INTRODUCTION TO SWITCHING THEORY.
(Com.S. 410) (3-0) Cr. 3. F.
Axiomatic development of Boolean algebra. Combinational circuits using AND, OR, NOT and other logic elements, truth tables, maps, minimization techniques. Introduction to asynchronous sequential circuits, stable and unstable states, state diagrams, flow tables, simplification methods.

411, 412. PRINCIPLES OF COMPUTER DESIGN.
(Com.S. 411, 412) 411: (3-2) Cr. 4; 412: (3-0) Cr. 3. W.S.
Prerequisite: 411: Com.S. 201, 410: 412: 411.
411: Digital computer organization. Arithmetic addition, subtraction, multiplication, division, negative representation. Control: instruction format, types, acquisition, execution. 412: Memory: organizations, types, hierarchies. Input output: methods, data organization. Arithmetic: speedup techniques, floating point operations. Control: advanced features.

421, 422, 423. LINES, WAVES AND RADIATION.
(3-3) Cr. 4 each. Yr.
Prerequisite: 421: 309, 314, Math. 321; 422: 421, Math. 322; 423: 422.
Transmission of electrical energy via lines, waves, and antennas. 421: Properties and applications of transmission lines, methods of analysis, impedance matching. 422: Plane waves, reflection and refraction, guided waves, resonators, dispersion characterisitcs. 423: Radiation, antenna theorems and properties, antenna systems, radiowave propagation in the earth's atmosphere. Laboratory: introduction to microwave measurements and instrumentation.

425. LINEAR INTEGRATED CIRCUITS.
(3-0) Cr. 3. W.
Prerequisite: 376.
Analysis and application of linear integrated circuits, including such topics as chip fabrication, monolithic differential and operational amplifiers, active filters, switching regulators, data sheet specifications.

426. PULSE AND DIGITAL CIRCUITS.
(3-3) Cr. 4. F.
Prerequisite: 376.
The diode and active devices in switching applications. Analysis and design of pulse and digital circuits such as linear sweeps, multivibrators, logic elements.

427. INTRODUCTION TO COMMUNICATION SYSTEMS ANALYSIS.
(3-0) Cr. 3. W.
Prerequisite: Math. 322.
Spectral analysis using Fourier series and Fourier transforms. Network impulse response and filtering. Transmission band-width requirements. Random signals and noise. Amplitude modulation systems and frequency-division multiplexing.

428. ELECTRICAL PROPERTIES OF MATERIALS.
(4-0) Cr. 4. S.
Prerequisite: 376, Phys. 303.
Electrical properties of metals, semiconductors, insulators, and magnetic materials as utilized in device applications such as lasers and integrated circuits.

431. ELECTRICAL ENERGY SOURCES.
(3-0) Cr. 3. W.
Prerequisite: 308 or 342 or 441, and Phys. 303.
Specialized and unconventional sources of electrical energy such as: photovoltaic generators (solar cells), thermionic converters, and magneto-hydrodynamic generators. Other energy conversion schemes.

436. DIGITAL INTEGRATED CIRCUITS.
(3-0) Cr. 3. S.
Prerequisite: 410, 426.
Analysis and application of digital integrated circuits. Analysis and comparison of several logic families and their applications to the design of counters, computers, and analog-to-digital converters.

441, 442. INTRODUCTION TO CIRCUITS AND INSTRUMENTS.
(3-2) Cr. 4 each. 441: F.W; 442: W.S.
Prerequisite: 441: Phys. 223, credit or classification in Math. 213; 442: 441.
441: Transient and steady state behavior of circuits. Use of the transfer function and the phasor transform in circuit analysis. Basic instruments. 442: Frequency response, bridge circuits, magnetically coupled circuits, transformers, periodic driving functions.

445, 446. ELECTRONIC CIRCUITS, INSTRUMENTS, AND SYSTEMS.
445: (3-3) Cr. 4. W.S; 446: (4-0) Cr. 4. S.
Prerequisite: 445: 342 or 441; 446: 445.
445: Introduction to electronic circuit analysis; diode and triode circuits; transistor circuits. 446: Electronic instrumentation and digital systems. Credit will not be allowed for both the 374, 375, 376 and the 445, 446 sequences.

451. INTRODUCTION TO ELECTRIC MACHINERY.
(3-2) Cr. 4. F.S.
Prerequisite: 442.
Three-phase circuit analysis. Power transformers. Basic principles of operation, design, and control of DC machines, induction machines, synchronous machines, and single phase machines.

452. ELECTRIC POWER MACHINERY.
(3-3) Cr. 4. S.
Prerequisite: 351 or 451.
Analysis of machine transients. Stability and control of multiphase and single phase machines.

465. INTRODUCTION TO ENERGY SYSTEMS.
(4-0) Cr. 4. F.
Prerequisite: 309, 351.
Electric energy requirements, structure of energy systems, energy resources, structure of bulk conversion schemes, thermal generation, hydro generation, future generation, economics of generation, structure of transmission systems, operation.

466, 467. POWER-SYSTEM ANALYSIS.
466: (4-0) Cr. 4. W; 467: (3-3) Cr. 4. S.
Prerequisite: 466: 465; 467: 466.
AC and DC transmission, transmission lines, generalized and graphical calculations, network analysis, load flow, system faults and fault calculations, transients and system insulation stability, economic operation.

475. INTRODUCTION TO ANALOG SIMULATION AND COMPUTATION.
(1-3) Cr. 2. F.W.S.
Prerequisite: Math. 321, credit or classification in 404.
Basic concepts of analog simulation and computation with applications to feedback systems.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

505, 506. CONTROL-SYSTEM ANALYSIS AND SYNTHESIS.
(3-0) Cr. 3 each. Offered as arr.
Prerequisite: 505: 404; 506: 505.
Analysis and synthesis of linear feedback systems using transfer-function and state-variable methods.

507, 508, 509. SEMICONDUCTOR DEVICE THEORY AND TECHNOLOGY.
(3-0) Cr. 3 each. Yr.
Prerequisite: 507: 376, Phys. 303; 508: 507; 509: 508.
507: Review of semiconductor physics including transport properties. Extensive theory and basic technology of p-n junction diode devices including tunnel and IMPATT diodes. 508: Theory of bipolar transistors and other multijunction devices. Introduction to surface state phenomenon. 509: Theory of selected surface effect, optoelectronic, and bulk effect devices. The concept and basic technology of integrated devices.

518, 519, 520. ELECTRIC AND MAGNETIC PROPERTIES OF MATERIALS.
(3-0) Cr. 3 each. Yr.
Prerequisite: 518: Phys. 303 or 423; 519: 518, Phys. 513 or Met. 512; 520: 519.
518: Crystal structure and symmetry, anisotropy, the phenomenological treatment of the physical properties of materials. 519: Band theory of solids. Conduction phenomena in metals, semi-conductors, and insulators. Junction phenomena. 520: Microscopic properties based upon quantum mechanics and statistical mechanics. Crystallography. Metals and transport phenomena. Magnetism and coupled-wave phenomena.

525. INTRODUCTION TO GASEOUS AND PLASMA ELECTRONICS.
(3-0) Cr. 3. Offered as arr.
Prerequisite: 314, Phys. 303.
Ionization processes; diffusion and recombination; electron attachment; behavior of charged particles in fields; mobility; self-sustained processes; breakdown; glows; arcs and coronas; microwave breakdown; plasma oscillations; plasma interaction with electromagnetic waves; applications.

527. COMMUNICATION SYSTEMS ANALYSIS AND DESIGN.
(3-3) Cr. 4. S.
Prerequisite: 427.
Angle modulation systems. Sampling theorem and practical sampling. Pulse modulation systems including pulse-code modulation. Time-division multiplexing. Information measure and channel capacity. Digital data systems. Design and comparison of systems.

531. NETWORKS AND LINEAR GRAPHS.
(3-0) Cr. 3. F. Alt. Yr. as arr.
Prerequisite: 309.
Analysis of networks by means of linear graph theory and matrix algebra. Network parameter matrices and their properties.

532. SYNTHESIS OF ELECTRIC NETWORKS.
(3-0) Cr. 3. Alt.Yr. as arr.
Prerequisite: 309.
Necessary and sufficient conditions and synthesis methods for realization of passive driving point functions.

533. SYNTHESIS OF ELECTRIC NETWORKS.
(3-0) Cr. 3. Alt.Yr. as arr.
Prerequisite: 532.
Approximations useful in network synthesis, synthesis of passive two-port networks.

534. SYNTHESIS OF ELECTRIC NETWORKS.
(3-0) Cr. 3. Alt.Yr. as arr.
Prerequisite: 533.
Properties of networks containing active elements and methods for synthesis of such networks.

539. MATRIX NETWORK ANALYSIS.
(3-0) Cr. 3. F.
Prerequisite: 309 or 442.
Matrix analysis of networks, port and terminal descriptions, linear vector space formulation and applications.

541. ADVANCED SYMMETRICAL COMPONENTS.
(3-0) Cr. 3. Alt.Yr. as arr.
Prerequisite: 467.
Calculation of sequence impedances, analysis of unbalanced systems and unbalanced conditions.

542. POWER SYSTEM PROTECTION.
(3-0) Cr. 3. Alt.Yr. as arr.
Prerequisite: 541.
Criteria for fault clearing, device coordination, relaying.

543. COMPUTER SOLUTIONS FOR POWER SYSTEMS.
(3-0) Cr. 3. Alt. Yr. as arr.
Prerequisite: 541; 539 or 506.
The study of algorithms adaptable to digital computers for load flow, fault, and stability problems.

544. DISTRIBUTION ENGINEERING.
(3-0) Cr. 3. Alt. Yr. as arr.
Prerequisite: 467.
Distribution components, design criteria, protective device coordination, secondary networks, voltage control.

546. ECONOMIC OPERATION OF POWER SYSTEMS.
(3-0) Cr. 3. Alt. Yr. as arr.
Prerequisite: 539.
Operation of systems on a minimal cost basis, theory of incremental loading, system losses, methods of computation.

547. HIGH VOLTAGE DC TRANSMISSION.
(3-0) Cr. 3. Alt. Yr. as arr.
Prerequisite: 314.
Transmission by direct current, inverter design, system simulation, parallel operation, stability considerations.

550. STATIC ELECTRIC AND MAGNETIC FIELDS.
(3-0) Cr. 3. F.
Prerequisite: 314.
Static electric and magnetic fields, potential theory, static fields in matter, solutions of Laplace's equation.

551, 552. ELECTROMAGNETIC FIELDS.
(3-0) Cr. 3 each. 551: W; 552: S.
Prerequisite: 551: 314 or 550; 552: 551.
551: Maxwell's equations, wave phenomena, theorems, and concepts. 552: Plane, cylindrical, and spherical wave functions, periodic structures, and anisotropic media.

554, 555. MICROWAVE ENGINEERING I AND II.
(3-0) Cr. 3 each. Alt. Yr. as arr.
Prerequisite: 554: 421; 555: 554.
554: One-port and two-port structures, the scatter matrix, impedance matching, directional couplers, microwave filters. 555: Microwave tubes and masers, parametric amplifiers, ferrite and solid-state semiconductor devices.

556. ANTENNA ENGINEERING.
(3-0) Cr. 3. Alt. Yr. as arr.
Prerequisite: 423.
Antenna properties and theorems, radiation from current elements and small antennas, array theory and pattern synthesis, introduction to the mathematical theory of antennas, radiation from apertures, broadband antennas, antenna measurements, special topics.

557. FUNDAMENTALS OF RADIO WAVE PROPAGATION.
(3-0) Cr. 3. Alt. Yr. as arr.
Prerequisite: 422.
Transmission loss, free-space propagation, propagation over plane and spherical surfaces, propagation at low frequencies, microwave and millimeter wave propagation, laser beam propagation.

560, 561, 562, 563. SYSTEMS ENGINEERING ANALYSIS.
(3-0) Cr. 3 each. 560, 561: Yr. as arr.; 562, 563: Alt. Yr. as arr.
Prerequisite: 560: Credit or classification in Math. 410 or Math. 415; 561: 560; 562: 561; 563: 561.
Applications of topics in abstract algebra, topology, theory of measure and integration, linear algebra, and functional analysis to automatic control systems and communication systems. Utilization of selected topics in ordinary differential equations, partial differential equations, calculus of variations, integral equations and random processes in the areas of communication and control theory.

565. INFORMATION THEORY I.
(3-0) Cr. 3. Alt. Yr. as arr.
Prerequisite: 427. Recommended corequisite: Stat. 541.
Application of probability to communication systems. Information content and redundancy of discrete sources. Noiseless coding and Shannon's noiseless coding theorem. Information measures for noisy channels. Shannon's fundamental theorem and error-correcting codes. Capacity of a continuous channel with additive noise.

566. INFORMATION THEORY II.
(3-0) Cr. 3. Alt. Yr. as arr.
Prerequisite: 565.
Variations of noiseless coding. Digital sequences having optimal correlation functions, with application to radar. Shift registers and pseudorandom sequences. Group codes for error detection and correction. Theory and implementation of cyclic error-correcting codes. Logic for correction of burst errors with recurrent codes.

567. INFORMATION THEORY III.
(3-0) Cr. 3. Alt. Yr. as arr.
Prerequisite: 565.
Statistical decision theory and application to digital communication systems. Optimal detection of signals in noise. Parameter estimation.

577, 578, 579. LINEAR SYSTEMS THEORY.
(3-0) Cr. 3 each. Offered as arr.
Prerequisite: 577: 404; 578: 427, 577; 579: 578.
Operational and state-space methods applied to the analysis and synthesis of both continuous and discrete linear systems. Controllability, observability, and stability.

582. SWITCHING THEORY.
(Com.S. 582) (3-0) Cr. 3. F.
Prerequisite: 410.
Review of combinational circuits. Sequential circuits, Mealy and Moore model, synchronous and asynchronous behavior, complete and incomplete machines, state minimization and state assignment procedures.

584, 585. DIGITAL SYSTEM ORGANIZATION.
(Com.S. 584, 585) (3-0) Cr. 3 each. 584: F; 585: W.
Prerequisite: 584: 411; 585: 584.
Influence of processing requirements on digital system structure; data flow paths in digital systems; data formats; channel organization; memory hierarchies; time sharing; interrupts and priorities; system optimization; system representation in Iverson Language.

586. DIGITAL SYSTEM DESIGN.
(Com.S. 586) (3-0) Cr. 3. S.
Prerequisite: 585.
Hardware systems simulation; advanced topics in design of arithmetic, logic, and control units; hardware system optimization; hardware-software trade-offs.

590. SPECIAL TOPICS.
Cr. 2 to 5 each time elected.
Formulation and solution of theoretical or practical problems in electrical engineering.

591, 592, 593. RANDOM PROCESS THEORY.
(3-0) Cr. 3 each. 591: Yr. as arr.; 592 and 593: Alt. Yr. as arr.
Prerequisite: 591: 404, Stat. 541 (recommended corequisite); 592: 591, 577; 593: 592.
Elements of probability. Mathematical description of a random process. Autocorrelation and spectral density functions. Response of linear systems to random inputs. Wiener filter theory. State-space formulation of random process. Recursive filtering techniques of Kalman. Engineering applications and other topics of current interest in random process theory.

COURSES FOR GRADUATE STUDENTS, major or minor

618, 619. ADVANCED TOPICS IN ELECTRICAL MATERIALS.
(3-0) Cr. 3 each time elected. Alt. Yr. as arr.
Prerequisite: 520.
A. Superconductivity.
B. Stimulated emission amplification.
C. Coupled wave phenomena.
D. Static and dynamic domain phenomena.

636, 637. LINEAR ACTIVE NETWORK THEORY.
(3-0) Cr. 3 each. Alt. Yr. as arr.
Prerequisite: 636: 539; 637: 636.
The foundations of the theory of linear active networks in the time- and frequency-domains. Active two-port networks. The scattering parameters of networks, broadband matching, and linear parametric networks.

641, 642. HIGH VOLTAGE ENGINEERING.
(3-0) Cr. 3 each. 641: Alt. Yr. as arr.
Prerequisite: 467, 525.
Need for high voltage, high fields, ionization, AC and DC corona, voltage transients, lightning and protection, insulator flashover, insulation coordination, circuit interruption, radio interference.

644, 645, 646. INTERCONNECTED POWER SYSTEM DYNAMICS.
(3-0) Cr. 3 each. Alt. Yr. as arr.
Prerequisite: 644: 467, 539, 506 or 579; 645: 644; 646: 645.
Dynamic performance of interconnected power systems with emphasis on stability. Dynamic equation of a synchronous machine and its response to perturbations. Control equipment in a power system including voltage regulators, governors and load-frequency controls. Representation of system components including the machine, the controls, and the loads during transients. Power system stability and the solution of the dynamic equations for large and small impacts using modern methods of analysis.

647. SPECIALIZED ELECTRIC ENERGY SOURCES.
(3-0) Cr. 3 each time elected. Alt. Yr. as arr.
Prerequisite: 431 or 314, 375; Phys. 303.
Study of specialized sources which convert various sources of energy into electric energy. Each time offered one of the following direct energy schemes will be discussed:
A. Photovoltaic generators (solar cells).
B. Thermionic converters.
C. Magnetohydrodynamic generators.
D. Other schemes.

650. NUMERICAL SOLUTIONS OF ELECTROMAGNETIC PROBLEMS.
(3-0) Cr. 3. Offered as arr.
Prerequisite: 552, Math. 406.
Variational and perturbational techniques, field computation by moment methods of radiating and scattering devices, eigenvalue problems, optimization.

677, 678, 679. NONLINEAR SYSTEMS.
(3-0) Cr. 3 each. 677: Yr. as arr.; 678 and 679: Alt. Yr. as arr.
Prerequisite: 677: 404; 678: 577, 677; 679: 678.
Analytical and graphical methods in the theory of nonlinear oscillations, including perturbation methods, averaging methods, describing functions, delta method, isocline method, classification of singularities. Stability of systems, including Lyapunov stability and instability, asymptotic stability, Lagrange stability, absolute stability, bounded input bounded output stability, practical stability. Problems of Lure, Aizerman, Popov. The circle criterion.

684. ADVANCED SWITCHING THEORY.
(Com.S. 684) (3-0) Cr. 3. Offered as arr.
Prerequisite: 410, permission of instructor.
Sequential logic with emphasis on the formalisms.

685. ADVANCED LOGIC SYSTEMS.
(Com.S. 685) (3-0) Cr. 3 each time elected. S.
Prerequisite: 586.
A. Specialized Processor Organization.
B. Pattern Recognition and Adaptive Systems.
C. Optical Systems.

689. COMPUTER SEMINAR.
Cr. 1 to 3 each time elected. Offered as arr.
Prerequisite: 586.
Various computer topics of timely interest.

691, 692, 693. OPTIMAL CONTROL.
(3-0) Cr. 3 each. 691: Yr. as arr.; 692 and 693: Alt. Yr. as arr.
Prerequisite: 691: 578; 692: 691; 693: 692.
Necessary and sufficient conditions for optimality. Lagrange multipliers. Variational approach to optimal control. Dynamic programming. Pontryagin's maximum (minimum) principle. The Hamilton-Jacobi equation. Design of time-optimal, minimum fuel, and minimum energy control systems. Structure and properties of optimal systems.

699. RESEARCH.

ENGINEERING

David R. Boylan, Ph.D., Dean of Engineering
Paul E. Morgan, M.S., Associate Dean
Burton J. Gleason, Assistant to the Dean

Graduate study for the degree Master of Arts with a major in the history of science and technology was developed jointly by the College of Engineering and the Department of History and is administered by the Department of History. Minor work is offered to students taking major work in other disciplines.

Prerequisite to major graduate work in the history of science and technology is the completion of at least 18 credits in history and 18 credits in science and/or engineering. See *History*.

COURSES FOR GRADUATE STUDENTS, minor only

431A, 431B. HISTORY OF ENGINEERING.
See History of Science and Technology.

433. SCIENCE AND MODERN THOUGHT FROM 1500 TO PRESENT.
See History of Science and Technology.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

515. HISTORY OF TECHNOLOGY IN THE UNITED STATES.
See History of Science and Technology.

561. TECHNOLOGY IN DEVELOPING COUNTRIES.
See History of Science and Technology.

590. SPECIAL TOPICS IN THE HISTORY OF TECHNOLOGY.
See History of Science and Technology.

591. SEMINAR: HISTORY OF SCIENCE.
See History of Science and Technology.

COURSES FOR GRADUATE STUDENTS, major or minor

699. RESEARCH.
See History of Science and Technology.

ENGINEERING MECHANICS

Harry J. Weiss, D.Sc., Head of Department

The Graduate Faculty

Members: H.J. Gilkey, K.G. McConnell, G.A. Nariboli, W.F. Riley, T.R. Rogge, Y.M. Tsai, H.J. Weiss, D.F. Young

Associate Members: L.A. Bertram, A.W. Davis, F.M. Graham, L.W. Schmerr, C.T. Sun, F.Y. Tsai

The department offers work for the degrees Master of Science, Master of Engineering, and Doctor of Philosophy with major in engineering mechanics, and minor work to students taking major work in other departments. The Master of Engineering degree is primarily a terminal master's degree, without thesis. There is no foreign language requirement for either master's degree or the Doctor of Philosophy degree.

The normal prerequisite to major graduate work is the completion of a curriculum substantially equivalent to that required of undergraduate students in engineering at this university. However, because of the diversity of interests in graduate work in engineering mechanics, it is possible for a student to qualify for graduate study even though his undergraduate or prior graduate training has been in a discipline other than engineering, e.g., physics or mathematics.

COURSES FOR GRADUATE STUDENTS, minor only

324. **STRENGTH OF MATERIALS.**
(5-0) Cr. 5. F.S.
Prerequisite: 274 or 275.
Plane stress, plane strain, stress-strain relationships, and elements of material behavior. Elements of stress and deformation analysis applied to members subject to centric, torsional, flexural, and combined loadings. Elementary considerations of theories of failure, buckling, repeated and impact loads. Credit cannot be received for both 324 and 325.

325. **MECHANICS OF MATERIALS I.**
(3-0) Cr. 3. F.W.S.SSI.
Prerequisite: 274 or 275.
Plane stress, plane strain, stress-strain relationships, and elements of material behavior. Elements of stress and deformation analysis applied to members subjected to centric, flexural, and torsional loads. Credit cannot be received for both 324 and 325.

326. **MECHANICS OF MATERIALS II.**
(3-0) Cr. 3. F.W.S.SS.
Prerequisite: 325.
Continuation of 325. Advanced topics on stress and deformation analysis of members subjected to torsional, flexural, and combined loading. Elementary considerations of theories of failure, buckling, repeated and impact loads.

*327. **MATERIALS LABORATORY.**
(0-3) Cr. 1. F.W.S.SSI.
Prerequisite: Credit or classification in 324 or credit in 325.
Experimental determination of mechanical properties of selected engineering materials. Experimental verification of assumptions made in 324. Use of strain measuring devices. Preparation of reports.

*337. **MATERIALS LABORATORY.**
(0-6) Cr. 2. F.W.
Prerequisite: Credit or classification in 354; credit in 325 or credit or classification in 324.
Similar to 327 with additional topics, and added emphasis on concrete. One-day inspection trip.

345. **PARTICLE DYNAMICS.**
(3-0) Cr. 3. F.W.S.SSI.
Prerequisite: 274, Math. 213.
Vector and scalar treatment of coplanar and noncoplaner kinematics. Force-mass-acceleration, work-energy, and impulse-momentum methods applied to the motion of particles and systems of particles.

346. **RIGID BODY DYNAMICS.**
(3-0) Cr. 3. F.W.S.SS.
Prerequisite: 345, Math. 321.
Vector and scalar treatment of coplanar and noncoplanar kinematics. Force-mass-acceleration, work-energy, and impulse-momentum methods applied to rigid body plane motion, motion about a point, and general space motion.

354. **ENGINEERING MATERIALS.**
(3-0) Cr. 3. F.W.S.
Prerequisite: Credit or classification in 324 or 325.
Properties, uses, and manufacture of metals, timber, stone, clay products, cements, concrete, and other engineering materials.

378. **MECHANICS OF FLUIDS.**
(3-2) Cr. 4. F.W.S.SSI.
Prerequisite: 345.
Properties of fluids. Fluid statics. Kinematics and kinetics of one-dimensional flow. Impulse-momentum, dimensional analysis, flow in pipes and channels, engineering applications. Selected laboratory experiments.

420. **INTRODUCTION TO MECHANICS.**
(4-0) Cr. 4. F.
Prerequisite: Phys. 111 or 221; Math. 213.
Selected topics in applied mechanics, including statics and dynamics of rigid bodies, concepts of stress and deformation, equations of motion for continuous media, dynamics of perfect fluids, elastic behavior of solids, and viscous flow. May be elected by engineering students desiring a general review of mechanics. However, E.M. 420 is not available for credit toward graduation for students who have completed E.M. 325 or E.M. 378 or their equivalent.

444. **MECHANICAL VIBRATIONS.**
(3-0) Cr. 3. F.W.
Prerequisite: 324 or 325; 346.
Elementary vibration analysis, single and multiple degrees of freedom, energy methods, free and forced vibrations, viscous damping, transmissibility, influence coefficients, lateral vibrations of beams.

490. **SPECIAL PROBLEMS.**
Cr. arr.
Prerequisite: Permission of instructor.

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* A student who is not present for the first laboratory meeting of his own section may qualify for continuation in the course only by attending the first laboratory meeting of some other section of either of these two courses.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

504, 505, 506. **ANALYTICAL METHODS IN MECHANICS.**
(3-0) Cr. 3 each. 504: F.SSI; 505: W.SSII; 506: S.
Prerequisite: Math. 411.
Applications of the equations of heat conduction, potential theory, and wave propagation to problems in mechanics. Methods of solution.

514. **ADVANCED MECHANICS OF MATERIALS.**
(3-0) Cr. 3. F.SSI.
Prerequisite: 324 or 326.
Theory of stress and strain, stress-strain relationships. Limitations of flexure and torsion formulas, unsymmetrical bending, curved beams, cross shear, shear center. Torsion of thin-walled and noncircular sections. Theories of failure, membrane stresses in shells, thick-walled cylinders.

515. **ELASTIC STABILITY.**
(3-0) Cr. 3. Alt. W, offered 1973.
Prerequisite: 514 or credit or classification in 594.
Stability of columns, beam-columns, and panels. Assumptions and limitations. Lateral buckling of beams. Torsion of thin-walled members.

517. **EXPERIMENTAL STRESS ANALYSIS.**
(3-2) Cr. 4. W.
Prerequisite: 324 or 326.
Fundamental concepts of strain measurement, properties of Stresscoat and its application, wire, foil and semi-conductor strain gages, strain gage circuits and recording instruments, rosette analysis, analogies, introduction to photoelasticity and moire methods.

518. PHOTOELASTICITY AND MOIRE METHODS.
(3-2) Cr. 4. Alt. S, offered 1972.
Prerequisite: 324 or 326.
Two- and three-dimensional photoelasticity, compensation techniques, principal stress separation using shear difference, oblique incidence and other methods, birefringent coatings, scattered light, design of models, moire methods and their application.

519. EXPERIMENTAL METHODS OF MOTION MEASUREMENT.
(2-2) Cr. 3. Alt. S, offered 1973.
Prerequisite: 517, 544.
Description, specifications, limitations, and applications of mechanical, electrical, and optical transducers used in motion measurements applied to steady state, transient, and shock motions. Calibration, signal conditioning, and transducer systems used to obtain reliable and reproducible experimental data. Seismic and absolute references for motion measurement.

544. MECHANICAL VIBRATIONS.
(3-2) Cr. 4. F.SSI.
Prerequisite: 325, 346.
Elements of lumped parameter linear systems, kinematics of vibrations, equations of motion for free and forced vibrations, energy methods, resonance, damping, multiple degrees of freedom, mechanical impedance, isolation and absorption of vibrations with impulsive and arbitrary exitation of linear systems, primary and residual shock spectra. Use of analog computers in analysis of vibration problems.

545. ADVANCED VIBRATION ANALYSIS.
(3-0) Cr. 3. Alt. W, offered 1972.
Prerequisite: 544, Math. 322.
Nonlinear vibrations, phase plane and approximate solutions. Multiple degrees of freedom, inertia and stiffness matrices, numerical methods. Vibration of continuous systems, limitations, and comparison of lumped approximations of continuous systems.

546. INTRODUCTION TO RANDOM VIBRATIONS.
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisites: 544.
Characteristics of random vibrations; random processes, probability distributions, spectral density and its significance, the normal or Gaussian random process. Transmission of random vibration, response of simple single and two-degree-of-freedom systems to stationary random excitation, failure due to random excitation.

548, 549, 550. ADVANCED ENGINEERING DYNAMICS.
(3-0) Cr. 3 each. Alt. Yr, offered 1972-73.
Prerequisite: 345, Math 321.
Dynamics of particles and rigid bodies applied to advanced engineering problems. Generalized coordinates. Hamilton's Principle, Lagrangian equations of motion, Hamilton-Jacobi equations, canonical transformations. Orbital motion. Stability of oscillatory motion. Nonlinear systems.

555. LINEAR WAVE PROPAGATION.
(3-0) Cr. 3. Alt. F, offered 1971.
Prerequisite: 506.
Surfaces of discontinuity, wave-fronts, characteristics, retarded potentials; reflection and refraction; anisotropy; dispersion and damping; phase velocity and group velocity; asymptotic methods.

566. ELASTIC PLATES.
(3-0) Cr. 3. Alt. W, offered 1972.
Prerequisites: 514 or 593.
Analysis of thin plates. Problems in the bending and buckling of thin plates.

568. PLASTICITY I.
(3-0) Cr. 3. Alt. W, offered 1973.
Prerequisite: 514 or 594.
Mechanical properties of materials beyond the elastic range. Yield criteria; Von Mises and Prandtl-Ruess stress-strain relations. Elastic-plastic analysis of simple structures. Plane strain and methods of characteristics.

569. INTRODUCTION TO LINEAR VISCOELASTICITY.
(3-0) Cr. 3. Alt. F, offered 1972.
Prerequisite: 594.
Definition of linear viscoelastic material; simple mechanical models; generalized models, differential and integral constitutive laws. Boundary value problems, transform methods, correspondence principle, variational techniques.

571, 572, 573. ADVANCED FLUID MECHANICS.
(M.E. 571, 572, 573) 571: (3-2) Cr. 4. F; 572: (3-0) Cr. 3. W; 573: (3-0) Cr. 3. S.
Prerequisite: 571: 378 or M.E. 424; 572: 571; 573: 571.
571: Fundamental relationships of fluid dynamics; real and ideal fluids; laminar and turbulent flow; flow in closed conduits and open channels; boundary layer theory; compressible flow, engineering applications. 572: Two- and three-dimensional potential flow problems; application of complex variables to two-dimensional fluid flow; conformal mapping; flow around solid bodies; free streamline theory. Applications to engineering problems. 573: Exact and approximate solutions to Navier-Stokes equations for one- and two-dimensional laminar flow problems, both steady and unsteady flows; exact and approximate solutions to one- and two-dimensional boundary layers; introduction to turbulent boundary layers.

590. SPECIAL TOPICS.
Cr. 2 to 5 each time taken.

593, 594, 595. THEORY OF ELASTICITY.
(3-0) Cr. 3 each. 593: Alt. F; 594: Alt. W; 595: Alt.S, offered 1972.
Prerequisite: 593: 324 or 325; 594: 593; 595: 594, credit or classification in Math. 411.
Fundamental relations of elasticity; uniform and nonuniform states of stress; Airy's function; application to engineering problems.

COURSES FOR GRADUATE STUDENTS, major or minor

604. ADVANCED TOPICS IN ANALYTICAL METHODS IN MECHANICS.
(3-0) Cr. 3. Alt. F, offered 1972.
Differential geometry of curves and surfaces; perturbation methods in solid and fluid mechanics; self-similar solutions; variational methods, Kantorovich's method, applied aspects of functional analysis.

620. SEMINAR.
(1-0) Cr. 1.

630. CONTINUUM MECHANICS I.
(3-0) Cr. 3. Alt. W, offered 1973.
Prerequisite: Math. 322.
Cartesian tensors; the second order tensor, principal values and Cayley-Hamilton theorem; Isotropic tensors, tensor fields, and orthogonal curvilinear coordinates; the stress tensor, simple kinematics, and conservation laws leading to constitutive laws for elasticity and fluid mechanics.

631. CONTINUUM MECHANICS II.
(3-0) Cr. 3. Alt. S, offered 1973.
Prerequisite: 630.
General tensors; curvilinear coordinate systems; kinematics, nonlinear elasticity, non-Newtonian fluids; objectivity, representation theorems, introduction to hypoelastic and viscoelastic materials.

635. RHEOLOGY.
(3-0) Cr. 3. Alt. W, offered 1973.
Prerequisite: 631.
Finite deformations; large strains, Green's right and left strain tensors. Elastic and hyperelastic materials, strain energy function, applications. Inverse methods of solution. Small strains superimposed on large initial strains. Introduction to hypoelasticity, finite viscoelasticity, and elastic fluids.

636. ADVANCED TOPICS IN RHEOLOGY.
(3-0) Cr. 3. Alt. S, offered 1973.
Prerequisite: 635.
Resume of group-invariant formulation, simple materials, polar materials, directors, and materials with memory. Thermodynamics. Further study of special topics of current interest.

650. FLUID MECHANICS SEMINAR.
(M.E. 650, Aer.E. 650)
(1-0 to 3-0) Cr. 1 to 3 each time taken.
Prerequisite: Permission of instructor.
Special topics of current research interest to students and staff of departments concerned.

651, 652, 653. ADVANCED THEORETICAL ASPECTS OF FLUID MECHANICS.
(3-0) Cr. 3 each. Alt. Yr, offered 1972-73.
Prerequisite: 651: 571; 652: 573; 653: 573.
651: Compressible flow: General considerations, theory of characteristics, shocks, detonation and deflagration waves, shock structure, similar solutions. 652: Viscous flow: Asymptotic methods in low and high Reynolds number flows, linear and nonlinear stability. 653: Turbulence: Isotropic turbulence, shear flows, jets and wakes, other recent theories.

655. NONLINEAR WAVE PROPAGATION.
(3-0) Cr. 3. Alt. W, offered 1972.
Prerequisite: 555.
Geometry of moving surfaces: Hadamard's lemma, compatibility conditions; simple waves; ray-theory; growth of waves of finite amplitude in continua; nonlinear dispersion.

661. ADVANCED TOPICS IN ELASTICITY.
(3-0) Cr. 3. Alt. F, offered 1972.
Prerequisite: 595.
Complex mapping techniques, three-dimensional problems, variational and energy principles, current literature.

666. INTRODUCTION TO ELASTIC SHELL THEORY.
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: 566.
Elementary differential geometry of surfaces. Deformation of thin shells.

668. PLASTICITY II.
(3-0) Cr. 3. Alt. S, offered 1973.
Prerequisite: 568.
Elastic-plastic torsion of cylindrical or prismatic bars, combined stresses. Lower bound and upper bound theorems of limit analysis. Extremum principles of Von Mises and Prandtl-Ruess. Discussion of current literature.

699. RESEARCH.

ENGINEERING SCIENCE

Glenn Murphy, Ph.D., Head of Nuclear Engineering

COURSES FOR GRADUATE STUDENTS, minor only

351. ENGINEERING MATERIALS.
(3-2) Cr. 4. W.
Prerequisite: Credit or classification in E.M. 325.
Resistance of materials to failure, definitions and evaluation of properties, relationship to design. Effects of environment on properties. Laboratory determinations.

352. ENGINEERING MATERIALS.
(3-2) Cr. 4. S.
Prerequisite: 351 or E.M. 354.
Structure of materials, and influence of structure upon properties. Properties of single crystals. Interatomic forces, energy considerations.

353. ENGINEERING MATERIALS.
(3-2) Cr. 4. F.
Prerequisite: 352.
Thermal and electrical characteristics, poly-crystalline systems, aggregates of domains. Engineering applications.

481, 482, 483. ENGINEERING ANALYSIS.
(3-2) Cr. 4 each. F.W.S.
Prerequisite: Chem. 321, E.M. 325, 345.
Application of the engineering sciences to the analysis of components and systems.

484. PRINCIPLES OF SIMILITUDE.
(3-2) Cr. 4. F.
Prerequisite: E.M. 325.
Dimensional analysis. Principles governing the design and operation of models for the solution of engineering problems. Analogies.

490. SPECIAL PROBLEMS.
Cr. 2 to 5.
Prerequisite: Permission of department head.
Investigation of an approved problem commensurate with the training, interest and ability of the student.

491. ENGINEERING DESIGN.
(1-6) Cr. 4. S.
Prerequisite: Credit or classification in 483.
Design problems in engineering science.

ENGLISH

Albert L. Walker, Ph.D., Chairman of Department

The Graduate Faculty

Members: D.R. Benson, L. Feinberg, K.G. Huntress, A.L. Walker, N.W. Yates

Associate Members: R.P. Bataille, J.A. Braun, D.K. Bruner, D.E. Cummings, P.G. Davies, A.E. Galyon, K.E. Gwiasda, R.C. Gustafson, F.E. Haggard, R.L. Herrnstadt, Q.G. Johnson, W.C. Jumper, C.B. Lipa, J.A. Lowrie, E.D. Mallam, T.D. Nostwich, R.C. Palmer, J.F. Speer, R. Zbaracki

The department offers work for the degree Master of Arts with major in English and minor work for students majoring in other departments. The master's degree ordinarily requires a thesis (6 credits); only in rare instances are nonthesis programs approved. Credits must include 530; 511 or 512; and usually 503. A reading knowledge of one foreign language is required, to be demonstrated by test or by course work at an advanced undergraduate level. Near the end of the program, candidates will be examined, in writing, on a number of literary works they have selected from a reading list and read independently.

Prerequisite to major graduate work is the completion of study substantially equivalent to the undergraduate major program in English at this institution.

Programs are designed to prepare students for: (1) further graduate study in language and literature, (2) teaching at the secondary, junior college, or beginning university level, (3) imaginative writing, scientific and technical writing, and editing.

In addition to the usual areas of study in literature and language, these special emphases are provided: (1) rhetorical, linguistic, and semantic analysis of factual and imaginative writing and of literary criticism; (2) scientific and technical writing; (3) study of the relations between science and imaginative literature and criticism.

COURSES FOR GRADUATE STUDENTS, minor only

363B. AMERICAN LITERATURE TO 1850.
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: 363A.
Literature of Colonial America. Significant American literary figures from 1600 to 1800.

364B. AMERICAN LITERATURE, 1850-1900.
(3-0) Cr. 3. Alt. F, offered 1972.
Prerequisite: 364A.
Realism in American literature. Significant writers and works in the rise of American realism between the Civil War and World War I.

374B. ENGLISH LITERATURE.
(3-0) Cr. 3. Alt. W, offered 1973.
Prerequisite: 374A.
Chaucer. Reading of The Canterbury Tales in Middle English.

375B. ENGLISH LITERATURE.
(3-0) Cr. 3. Alt. W, offered 1972.
Prerequisite: 375A.
Milton and his contemporaries. Selected poetry and prose of Milton and his contemporaries, with emphasis on the poetry of Milton, Marvell, and Dryden.

376B. ENGLISH LITERATURE.
(3-0) Cr. 3. Alt. S, offered 1973.
Prerequisite: 376A.
The Romantic Movement, Blake, Burns, and minor precursors of romanticism; Wordsworth, Coleridge, Scott, Byron, Shelley, Keats, Lamb, Hazlitt, DeQuincey.

392A, 392B. THE ENGLISH NOVEL TO 1900.
(3-0) Cr. 3 each. 392A: Alt. W, offered 1973; 392B: Alt. S, offered 1973.
Prerequisite: 201.
392A: Development of the English novel to 1832. 392B: The Victorian novel.

414. WRITING OF REPORTS AND TECHNICAL PAPERS.
(3-0) Cr. 3. F.W.S.SS.
Prerequisite: 105; graduate classification.
Technical, research, and business report writing. Principles of technical exposition. Writing of reports, preferably on topics from the student's own discipline. (For advanced projects see Engl. 507.)

419. MODERN GRAMMAR.
(3-0) Cr. 3. F.W.SSI.
Prerequisite: 105.
Modern grammar and linguistics; methods of grammatical analysis.

420. DEVELOPMENT OF THE ENGLISH LANGUAGE.
(3-0) Cr. 3. S.
Prerequisite: 105.
Background and development of the English language; its relationships with other languages of the past and present; modern English grammar; contemporary developments in the language.

450. LITERARY CRITICISM.
(3-0) Cr. 3. S.
Prerequisite: 354A, 464A.
The nature of criticism; ideas and attitudes of critics from early times to the present; relationships between literature and psychology. Literary scholarship as related to criticism. The book review as a critical form.

464B. SHAKESPEARE.
(3-0) Cr. 3. W.
Prerequisite: 464A.
Shakespeare's development as a dramatist. Intensive study of selected plays, with emphasis on Shakespeare's development as a playwright; background of the period; introduction to Shakespearean scholarship.

476. VICTORIAN POETRY.
(3-0) Cr. 3. Alt. F, offered 1972.
Prerequisite: 376A.
Selected Victorian poets with attention to later and transitional figures. Aspects of the Victorian age reflected in the poetry.

477. VICTORIAN PROSE.
(3-0) Cr. 3. Alt. W, offered 1973.
Prerequisite: 376A.
Selected Victorian prose. Aspects of the Victorian age reflected in the prose.

495. TEACHING ENGLISH TO SPEAKERS OF OTHER LANGUAGES.
(3-0) Cr. 3. W.
Methods and materials for teaching English as a second or foreign language, or as a standard dialect for the disadvantaged. Familiarity with linguistic terminology is useful, but not required.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

503. PROBLEMS IN WRITTEN COMMUNICATION.
(3-0) Cr. 3. W.SSII.
Prerequisite: Permission of instructor.
For secondary, junior college, or college teachers. Current communication theory with applications. Evaluation of writing and definition of standards. Secondary and college writing programs.

504. ADVANCED IMAGINATIVE WRITING.
(3-0) Cr. 1 to 3 each time taken, maximum of 9. F.W.S.SSII.
Prerequisite: 304A or B, permission of instructor one quarter before course begins.
Individual projects.

507. SCIENTIFIC AND TECHNICAL WRITING.
Cr. 1 to 3 each time taken, maximum of 6. F.W.S.SSI.
Prerequisite: Permission of instructor one quarter before course begins.
Technical language and style. Analysis and writing of scientific prose, including abstracts, manuals, proposals, and other technical papers. Individual projects. Directed readings.

511. INTRODUCTION TO GENERAL LINGUISTICS.
(3-0) Cr. 3. W. Alt. SSI, offered 1973.
Prerequisite: Permission of instructor.
Principles of general linguistics; history of the development of modern linguistic science.

512. PROBLEMS IN THE HISTORY OF THE ENGLISH LANGUAGE.
(3-0) Cr. 3. S. Alt. SSI, offered 1972.
Prerequisite: Permission of instructor.
Historical linguistics; application to selected problems in the development of the English language.

522. THEORY OF LITERATURE.
(3-0) Cr. 3. S. Alt. SSI, offered 1973.
Prerequisite: Nine credits in literature beyond 201.
Application of critical principles to literary problems and controversies. Clarification of terminology; examination of critical generalizations and assumptions.

523. EXPERIMENTAL DRAMA.
(3-0) Cr. 3. Alt. S, offered 1972. Alt. SSI, offered 1973.
Prerequisite: Nine credits in drama.
Significant trends in British, American, and Continental drama since World War II.

530. BIBLIOGRAPHY AND RESEARCH METHODS.
(3-0) Cr. 3. F.SSI.
Prerequisite: Eighteen credits in literature.
Required of candidates for the master's degree.

532. MODERN SATIRE.
(3-0) Cr. 3. Alt. S, offered 1973. Alt. SSII, offered 1973.
Prerequisite: Nine credits in American, British, or world literature.
Satire since World War I.

534. SCIENCE AND LITERARY IMAGINATION.
(3-0) Cr. 3 each time taken, maximum of 9. Alt. F, offered 1971.
Prerequisite: Nine credits in British or American literature.
Imaginative literature and criticism from a selected historical period, considered with reference to concurrent developments in science. Emphasis on literary world picture, metaphor, and language theory.

562. AMERICAN TRANSCENDENTALIST WRITERS.
(3-0) Cr. 3. S. Alt. SSI, offered 1973.
Prerequisite: Nine credits in American literature including 363A.
Transcendentalism as a force in American literature, with main emphasis on philosophic origins, the American scene, and the writings of Emerson, Thoreau, and the minor transcendentalists.

563. THE AMERICAN NOVEL.
(3-0) Cr. 3 each time taken, maximum of 6. F. SSII.
Prerequisite: Nine credits in American literature including 364A.
Major developments in the American novel to 1900.

564. SIGNIFICANT AMERICAN NONFICTION.
(3-0) Cr. 3. Alt. W. and SSI, offered 1972.
Prerequisite: Nine credits in American literature including 364A.
Idealism, realism, and skepticism since the 1840's, as reflected by essayists of distinction: Emerson, Thoreau, Twain, William James, Henry Adams, Veblen, Santayana, Bourne, Mencken, E.B. White, and others.

566. MAJOR AMERICAN POETS.
(3-0) Cr. 3 each time taken, maximum of 6. W. Alt. SSII, offered 1973.
Prerequisite: Nine credits in American literature including 364A.
Major American poets from Edward Taylor through Eliot and Frost, but with particular emphasis on such nineteenth century figures as Bryant, Emerson, Whitman, Dickinson, and Melville.

570. ENGLISH POETRY OF THE SEVENTEENTH CENTURY.
(3-0) Cr. 3. Alt. W. and SSII, offered 1973.
Prerequisite: Nine credits in English literature including 375A.
Development of English poetry from Donne to Dryden. Concentration on a few selected authors, excluding Milton.

571. THE AUGUSTANS.
(3-0) Cr. 3 each time taken, maximum of 6. Alt. F, offered 1971, Alt. SSII, offered 1972.
Prerequisite: Nine credits in English literature including 375A.
Selected neoclassic writers in verse and prose: Dryden, Addison, Pope, Johnson, and their circles.

573. ENGLISH LITERATURE OF THE RENAISSANCE (EXCLUDING DRAMA).
(3-0) Cr. 3 Alt. F, offered 1972. Alt. SSI, offered 1973.
Prerequisite: Nine credits in English literature including 374A.
Poetry and prose of the sixteenth and early seventeenth centuries.

574. CHAUCER.
(3-0) Cr. 3. F. Alt. SSI, offered 1972.
Prerequisite: Nine credits in English literature including 374A.
Intensive study of selected Canterbury Tales and minor poems. Introduction to Chaucer scholarship.

575. MILTON.
(3-0) Cr. 3. S. Alt. SSII, offered 1972.
Prerequisite: Nine credits in English literature including 375A.
***Paradise Lost*, with other poems and selections from the prose.**

576. ROMANTIC WRITERS.
(3-0) Cr. 3 each time taken, maximum of 6. Alt. F. Alt. SSI, offered 1972.
Prerequisite: Nine credits in English literature including 376A.
Wordsworth, Coleridge, and selected minor contemporaries. Byron, Shelley, and Keats and selected minor contemporaries.

577. VICTORIAN WRITERS.
(3-0) Cr. 3 each time taken, maximum of 6. Alt. W, offered 1973; Alt. SSII, offered 1972.
Prerequisite: Nine credits in English literature including 376A.
Selected Victorian and Edwardian authors.

579. BRITISH DRAMA, 1660-1714.
(3-0) Cr. 3. Alt. W, offered 1973. Alt. SSI, offered 1972.
Prerequisite: Nine credits in English literature including 375A.
Restoration and 18th-century comedy, and heroic tragedy, as seen in the plays of Dryden, Wycherley, Congreve, and minor dramatists.

580. SHAKESPEARE.
(3-0) Cr. 3. W. SSII.
Prerequisite: Nine credits in English literature including 464B.
Shakespeare as poet and dramatist. Chief critical schools and areas of scholarship.

589. SEMINAR.
Cr. var.
Prerequisite: Permission of instructor.
A. Individual authors.
B. Literary periods and movements; history of ideas.
C. Genres.
D. Theory and criticism.
E. Language and linguistics; semantics.

590. SPECIAL TOPICS.
Cr. var.
Prerequisite: Permission of department chairman.
A. Linguistics; semantics.
B. Literature; criticism.
C. Rhetorical analysis; communication.

COURSES FOR GRADUATE STUDENTS, major or minor

689. GRADUATE SEMINAR.
Cr. var. F.W.S.SS.
Prerequisite: Eighteen graduate credits, permission of department chairman.
A. Linguistics; semantics.
B. Literature; criticism; theory of literature.
C. Rhetorical analysis; communication.

699. RESEARCH.

FAMILY ENVIRONMENT

Ronald C. Powers, Ph.D., Head of Department

The Graduate Faculty

Members: E. Beveridge, M.I. Liston, L.J. Peet, R.C. Powers

Associate Members: M.A. Budolfson, A.R. Coveney, M. Heltsley, A. Peterson, M.S. Pickett, E. Schwieder, H.L. Wells, D.A. Weltha

The department offers work for the degree Master of Science with major in family environment and minor work for students taking major work in other departments. Work may be taken for the degree Doctor of Philosophy as a joint major with departments such as Home Economics Education, Child Development, Food and Nutrition, Economics, Physics, Chemistry,

and Sociology and Anthropology. The department cooperates in both the water resources program and the housing program. See *Water Resources* and *Housing*.

Prerequisite to major work in family environment is the completion of at least 15 credits in each of the following areas: communicative arts, humanities, physical and biological sciences, and social and behavioral sciences. The student should also have the equivalent of the courses generally considered as introductory principles in the family environment program at this institution. Students emphasizing the physical aspects of family environment should have the basic work in equipment and food preparation. Educational background in the biological, chemical, physical, or social sciences may be suitable, depending on the student's objectives.

There is no stipulated foreign language requirement for graduate study. All requirements are the responsibility of the student's advisory committee, subject to approval of the department head.

COURSES FOR GRADUATE STUDENTS, minor only

308. MODERN LIGHTING FOR RESIDENTIAL INTERIORS.
(2-4) Cr. 3. F.W.S.
Prerequisite: Three credits in housing and equipment, permission of instructor.
Lighting as a design factor to meet needs of individuals and families for task, general, and decorative purposes. Light sources and techniques to implement objectives in design.

340. HOUSING FOR SPECIAL GROUPS.
(3-0) Cr. 3. S.
Prerequisite: 240.
The housing problems of the low-income, minority, and physically limited segments of our society. Programs and research currently being conducted or proposed toward solution of the housing problems of these groups.

408A, 408B. EQUIPMENT FOR CARE OF MODERN FABRICS.
408A: (3-0) Cr. 3. S. 408B: (0-3) Cr. 1. S.
408A: Survey of equipment, materials, and procedures designed for modern fabric care. Relationship of performance to methods of care. Review of research and current literature. 408B: Laboratory experimentation. Concurrent registration in 408A is required.

410. FOOD-RELATED MAJOR HOME APPLIANCES.
(3-3) Cr. 4. W.
Prerequisite: 254, F.& N. 208.
Evaluation of ranges, refrigerators, and food freezers designed for use in homes. New developments and basic characteristics of these appliances affecting their selection and utilization by consumers.

412. KITCHEN, BATH, AND UTILITY AREA PLANNING.
(2-4) Cr. 3. W.
Planning of kitchen, bath, and utility areas for form, function, and economy; problems of effective use of utilities; remodeling.

415. CONSUMER BEHAVIOR.
(3-0) Cr. 3. F.W.
Prerequisite: Three credits of psychology, Soc. 134, Econ. 241 or 242.
Dimensions of consumer behavior; consumer competence; interaction of consumers, government and the marketing system; processes of consumer choice; evaluation of consumer information and protection. Field trip.

445. RESIDENTIAL UTILITIES.
(2-3) Cr. 3. F.
Prerequisite: 240, 254.
Relationship of comfort, health, and safety to electric wiring, plumbing, heating, cooling, and communications systems used in the home. Consumer responsibility for solution of air- and water-pollution problems.

446. HOUSING ALTERNATIVES FOR INDIVIDUALS AND FAMILIES.
(2-3) Cr. 3. F.
Prerequisite: 240.
Meeting human needs through alternative housing forms. Emphasis on internal housing environment as influenced by technological and physical factors.

470. COMMUNICATION WITH FAMILIES.
(3-0) Cr. 3. F.W.
Prerequisite: 270, 385.
Principles of communicating with families of different socioeconomic levels. Exploration of the role of empathy and sensitivity in establishing helping relationships with families.

485. PLANNING CHANGE IN THE FAMILY ENVIRONMENT.
(3-0) Cr. 3. S.
Prerequisite: Permission of the instructor.
Methods of identifying and analyzing problems in the environment of families. Techniques of involving families in effective processes of planning change.

488. FAMILY FINANCE.
(3-0) Cr. 3. F.W.S.SSI.
Prerequisite: Three credits of psychology, Soc. 134, Econ. 241 or 242.
Managerial approaches to financial problems of families. Decision making relative to acquiring and allocating income. Financial management focused on consumer credit, savings and investment, insurance, home ownership, and estate planning.

489. MANAGERIAL RESOURCES AND PROCESSES IN FAMILY LIFE.
(2-3) Cr. 3. F.S.
Prerequisite: 375.
Processes involved in management of family resources of human capital, property, and community opportunities, as well as money, time, space, and natural environment.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

500. FAMILY ENVIRONMENT SHORT COURSES.
Cr. arr. SS.
Short courses designed primarily for special groups. Credits are not accepted for graduate credit in family environment. Short courses are offered under the following general designations.
A. Family Relations and Human Development.
B. Housing.
C. Consumer Economics and Management.
D. Household Equipment.
G. General Family Environment.

504. RESEARCH METHODS AND TECHNIQUES.
(2-4) Cr. 4. F.
Research methods and techniques applicable to studies of the family as and in environment. Emphasis on research design and problem selection.

519. CONSUMER DYNAMICS.
(3-0) Cr. 3. S.
Prerequisite: 415, 488.
Consumer roles in the evolution of economic society. Analysis of changes in consumer interactions with public and private institutions serving consumer interests.

521. HOUSING AND SOCIAL ENVIRONMENT.
(3-0) Cr. 3. S.
Prerequisite: 240 or equivalent, Econ. 241 or 242, three credits of psychology, Soc. 134.
Human housing as related to social environments: political, economic, and sociological. Management of housing for human development. Emphasis on research.

522. TIME AND HUMAN RESOURCES.
(3-0) Cr. 3. W.
Prerequisite: 375.
Time, space, and human attributes as basic resources in family life. Social and technical concepts for furthering attainment of family goals through work and leisure.

523. MANAGEMENT WITHIN FAMILY ENVIRONMENT.
(3-0) Cr. 3. S.
Prerequisite: 375.
Philosophy and trends of management in the family related to environmental conditions and socioeconomic levels.

540. ADVANCED STUDIES IN HOUSEHOLD EQUIPMENT.
(2-3) Cr. 3 each time elected. Alt. F, offered 1971.
Prerequisite: 504, 12 credits of household equipment.
Experimental study of appliances designed for automating tasks related to food storage, preparation, and cooking; care and construction of modern fabrics; and maintenance of health, comfort, and convenience in the home. Planning and conducting performance tests for studying suitability of appliance for performing intended service to families.

570. THE INDIVIDUAL AND FAMILY DEVELOPMENT.
(3-0) Cr. 3. F.W.SSI.
Prerequisite: Twelve credits in behavioral sciences.
Experiential learning and encounter with ways that interpersonal relationships contribute to the development of human potential for individuals and families.

575. CULTURAL FOUNDATIONS OF FAMILY LIFE.
(3-0) Cr. 3. F.
Prerequisite: Nine credits in behavioral sciences.
Cultural influences in individual and family development; roles of family members; values, customs, taboos, and rituals related to family life.

579. DYNAMICS OF FAMILY RELATIONSHIPS.
(3-0) Cr. 3. S.
Prerequisite: Nine credits in psychology.
Theories of family relations and individual development. Emphasis on the development of healthy, full-functioning individuals and the family environment that contributes to this development.

588. FAMILY ECONOMICS.
(3-0) Cr. 3. F.
Prerequisite: Econ. 241 or 242; 3 credits in psychology, Soc. 134.
Problems of measuring family income, wealth, and welfare. Programs for improving adequacy and security of income during family life cycle. Factors which influence standards and levels of living.

590. SPECIAL TOPICS.
Cr. arr.
Prerequisite: Permission of instructor.
A. Family Relations and Human Development.
B. Housing.
C. Consumer Economics and Management.
D. Household Equipment.
F. Field Trips and Field Experience.
G. General Family Environment.

591. PRACTICUM IN FAMILY ENVIRONMENT.
(As arr.) Cr. 1 to 6 each time elected.
Prerequisite: Completion of 15 credits of graduate coursework.
Supervised experience in the following areas of family environment.
A. Family Relations and Human Development.
B. Housing.
C. Consumer Economics and Management.
D. Household Equipment.
G. General Family Environment.

COURSES FOR GRADUATE STUDENTS, major or minor

604. SEMINAR.
Cr. 1 to 3. F.W.S.
A. Family Relations and Human Development.
B. Housing.
C. Consumer Economics and Management.
D. Household Equipment.
G. General Family Environment.

699. RESEARCH.
Cr. arr.
A. Family Relations and Human Development.
B. Housing.
C. Consumer Economics and Management.
D. Household Equipment.
G. General Family Environment.

FOOD AND NUTRITION

Wilma D. Brewer, Ph.D., Head of Department

The Graduate Faculty

Members: L. Arnrich, W.D. Brewer, M.A.F. Carlin, E.S. Eppright, M.A. Kenney, E.M. Miller, C.E. Roderuck

Associate Members: P. Garcia, T.J. McMillan, T.J. Runyan, W.S. Runyan

The department offers work for the degree Master of Science with majors in food science, nutrition, and food and nutrition, and for the degree Doctor of Philosophy with majors in food science and in nutrition, and minor work for students majoring in other departments.

Prerequisite to major work is the completion of a curriculum in food and nutrition substantially equivalent to that required of undergraduates at Iowa State University. Students with undergraduate majors in biological and physical sciences are qualified for graduate study in food science and nutrition.

Students taking major work for the degree Doctor of Philosophy either in food science or in nutrition may choose minors to further their interests in related areas. Minors may be selected from other fields of home economics as well as from chemistry, biochemistry, bacteriology, economics, food technology, journalism, psychology, physiology, or statistics. There is no foreign language requirement for the degree Master of Science. For the degree Doctor of Philosophy, the foreign language requirement may be met by: (1) demonstration of a satisfactory reading knowledge of two languages (French, German, Spanish, Russian); (2) competence in communication in one of the above languages as demonstrated by examination or as indicated by two years of course work (C grade or better) in the baccalaureate program.

COURSES FOR GRADUATE STUDENTS, minor only

305. NUTRITION AND DIETETICS.
(3-3) Cr. 4. F.W.S.
Prerequisite: Three credits in biochemistry; Biol. 101 or Zool. 155. McMillan.
Physiological and chemical bases for nutrient needs; factors to consider in satisfying these needs for individuals and populations.

409. DIET THERAPY.
(4-0) Cr. 4. F.W.
Prerequisite: 305.
Basic biochemical and physiological conditions which necessitate dietary modification as a part of the therapeutic management of the patient; role of dietitian in hospital and other health services.

410. NUTRITION DURING HUMAN GROWTH AND DEVELOPMENT.
(2-2) Cr. 3. F.S.
Prerequisite: 305.
Nutritional needs during growth and reproduction; problems in feeding infants, children, and women during the reproductive period; indices of growth and development.

413. COMMUNITY NUTRITION.
(2-3) Cr. 3. F.
Prerequisite: 305.
Survey of current public health nutrition problems; food misinformation; food habits of population groups which have a high incidence of malnutrition; discussion of community programs designed to help solve problems. Field trips in conjunction with programs of Iowa State Department of Health or Cooperative Extension Service.

414. SEMINAR IN COMMUNITY NUTRITION.
(2-0) Cr. 2. S.
Prerequisite: 413.
Methods used in making dietary studies and judging apparent nutritional status; use of findings in planning community nutrition programs.

500. SHORT COURSE.
Cr. arr. SS.
Prerequisite: Permission of instructor.

521, 522, 523. SELECTED STUDIES IN FOOD SCIENCE.
(1-6) Cr. 3 each. Yr.
Prerequisite: 215, B.&B. 301 or 311; Bact. 300.
521, 522: Experimental approach to the study of chemical and physical properties of interactive components of selected foods; correlated emphasis on selection, application, and evaluation of pertinent literature. 523: Individual design, execution, and summarization of the laboratory investigation of a problem in food research. Emphasis on development of critical evaluation and interpretation of data and supporting literature.

550. PROCESSED FOODS.
(3-0 or 6) Cr. 3 or 5. S.
Prerequisite: 411; 421 or 521. Carlin.
Physical and chemical aspects of commercially prepared foods; methods of standardization, preservation, evaluation of quality.

590. SPECIAL TOPICS.
Cr. arr.
Prerequisite: 305.
A. Nutrition.
B. Food Science.
C. Professional Problems.

COURSES FOR GRADUATE STUDENTS, major or minor

601. **PRINCIPLES OF NUTRITION.**
(3-0) Cr. 3. W.
Prerequisite: 305, B.&B. 305.
Advanced study of nutrition. Required of all graduate students in the department.

606. **CHEMICAL METHODS FOR RESEARCH IN FOOD AND NUTRITION.**
(1-9) Cr. 4. W.
Prerequisite: 305; Chem. 211 or equivalent. Kenney.
Application of chemical techniques to research in nutrition.

607A, 607B. **ANIMAL EXPERIMENTATION IN NUTRITION RESEARCH.**
607A: (1-0 or 3) Cr. 1 or 2. W; 607B: (0-6) Cr. 2. S.
Prerequisite: 606 or Chem. 211 or equivalent. Arnrich.
The animal feeding experiment as a technique in nutrition research. Two quarters taken consecutively are required. Principles and basic experimental design using small laboratory animals. Individual problems in the animal laboratory.

609. **SEMINAR.**
Cr. R; F.W.S.
Required of all graduate majors in the Food and Nutrition Department.

615. **ADVANCED NUTRITION.**
(3-0) Cr. 3 each time elected. F.S.
Prerequisite: 601. Arnrich, Kenney, Roderuck, Runyan.
Series of one-term courses on such topics as proteins, vitamins, minerals, lipids, energy metabolism, evaluation of nutritional status. Classical and current research literature in each area.

619. **RESEARCH METHODS IN FOOD SCIENCE.**
(1-6) Cr. 3. F. or W.
Prerequisite: 521, 606. Carlin.
Application of physical, chemical, and organoleptic techniques to research in food science.

620. **ADVANCED FOOD SCIENCE.**
(3-0 or 2) Cr. 3 or 4.
Prerequisite: 619. Carlin.
Physical and chemical behavior of basic food constituents. Series of nonsequence courses on such topics as protein, fat, carbohydrate.

680. **MODERN VIEWS OF NUTRITION.**
(An.S. 680). See Animal Science.

699. **RESEARCH.**
A. Nutrition.
B. Food Science.

FOOD TECHNOLOGY

Verner H. Nielsen, Ph.D., Head of Department

The Graduate Faculty

Members: E.W. Bird, D.E. Goll, E.G. Hammond, P.A. Hartman, E.A. Kline, A.A. Kraft, W.W. Marion, V.H. Nielsen, G.W. Reinbold, H.E. Snyder, M.H. Stromer, H.W. Walker

Associate Members: F.C. Parrish, D.C. Topel

The department offers work for the degrees Master of Science and Doctor of Philosophy with majors in food technology, dairy microbiology, and meat science, and minor work for students majoring in other departments. Graduate work in meat science is offered as a joint major in animal science and food technology.

Prerequisite to major graduate work is the satisfactory completion of an undergraduate curriculum essentially equivalent to the food technology curriculum offered in this department or the completion of a curriculum in a related science such as dairy technology, bacteriology, chemistry, biochemistry, or engineering. Preparation in biology, chemistry, physics, and calculus along with knowledge of food processing, sanitation, and preservation are particularly desirable for those intending to pursue graduate work.

The foreign language requirement for the degree Master of Science is a reading knowledge of one foreign language, as evidenced by a score of 400 or more on the ETS examination. The foreign language requirement for the degree Doctor of Philosophy is a reading knowledge of one foreign language, as evidenced by a score of 500 or more on the ETS examination and by satisfactory completion of one year of college study in the same language. German, French, Russian, and Spanish are acceptable foreign languages. Other languages, including English for foreign students, may be acceptable based on the judgment of the student's advisory committee.

Courses open to graduate students for minor credit only: 305, 306, 307, 412, 414, 449, 450, 491, 492, 493. Exceptions may be made for graduate majors whose undergraduate preparation was not in food or a food-product technology but in a related science. Upon approval of their advisory committees, they may take food technology courses with 400 numbers for graduate credit.

COURSES FOR GRADUATE STUDENTS, minor only

305. PROCESSING AND MARKETING OF FLUID MILK.
(3-0 or 6) Cr. 3 or 5. F.
Prerequisite: Chem. 231 or 335; Bact. 300.
The application of microbiology, chemistry, and mechanics to the procurement, processing, and distribution of market milk; sanitary standards; control of chemical and bacteriological defects.

306. DAIRY PRODUCTS TECHNOLOGY I.
(3-0 or 6) Cr. 3 or 5. W.
Prerequisite: 305.
Properties and reactions of milk fat in butter and related products. Theories and technology of cream separation and churning. Butter manufacture. Condensed and dry milk manufacture.

307. DAIRY PRODUCTS TECHNOLOGY II.
(3-0 or 6) Cr. 3 or 5. S.
Prerequisite: 305.
Technology of manufacture and marketing of domestic and foreign cheese. Manufacture of ice cream and related products.

412. FOOD PRESERVATION.
(3-0 or 6) Cr. 3 or 5. S.
Prerequisite: Bact. 300.
Preservation, maintenance of quality of food products. Field trips.

414. FOOD, MILK AND WATER SANITATION.
(3-0 or 6) Cr. 3 or 5. W.
Prerequisite: Bact. 300.
Control of biological, chemical, and physical environments in maintaining proper sanitation and safety of foods and water. Regulations governing sanitation. Field trips.

449. FOOD CHEMISTRY.
(3-6) Cr. 3 or 5. F.
Prerequisite: Chem. 231 or 335. For students taking the laboratory, Chem. 211 or permission of instructor.
The structure, properties, and reactions of important food constituents and basic food commodities. The analysis and composition of food products.

450. DAIRY MICROBIOLOGY.
(3-6) Cr. 5. F.
Prerequisite: Bact. 300.
Beneficial and harmful microorganisms in milk and milk products. Standard methods of bacteriological analysis. Prevention of microbial spoilage.

491, 492, 493. INTRODUCTION TO FOOD PROCESSING SYSTEMS.
(3-0 or 3) Cr. 3 or 4. F.W.S.
Prerequisite: Math. 110 or 162; Phys. 112.
491: Power transmission, materials handling, electric motors, grinding and size classification.
492: Fluid properties and flow, dimensional analysis, hydraulic transfer, mixing, heat transfer, insulation.
493: Gas law, power cycles, refrigeration, and drying.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

547. FOOD TECHNOLOGY.
(2 or 3-0) Cr. 2 or 3. F.W.S.
Prerequisite: Permission of instructor.
Selected topics in food technology. Schedule of presentation will be announced.

559. ADVANCED DAIRY MICROBIOLOGY.
(3-0 or 6) Cr. 3 or 5. W.
Prerequisite: 450. Reinbold.
Intensive study of microorganisms in milk products. Importance of beneficial and defect-producing microorganisms in manufacturing, packaging, and storing milk products.

COURSES FOR GRADUATE STUDENTS, major or minor

623. TOPICS IN FOOD CHEMISTRY.
(3-0) Cr. 3. W.
Prerequisite: 449 or permission of instructor.
The chemistry of processes leading to changes in flavor, texture, or color in foods.

640. FOOD PROTEINS.
(3-0) Cr. 3. Alt. F, offered 1971.
Prerequisite: B.&B. 404 or permission of instructor.
Fundamental properties of protein systems found in milk, eggs, meat, and cereal grains. Effect of processing on food proteins.

656. ADVANCED FOOD MICROBIOLOGY.
(5-0) Cr. 5. S.
Prerequisite: 450, Bact. 413 or permission of instructor.
Relation of the physiological and taxonomic grouping of microorganisms to the processing technology of dairy products, meats, poultry, eggs, fruits, and vegetables.

660. SEMINAR.
(1-0) Cr. 1. F.W.S.

670. SPECIAL PROBLEMS IN FOOD TECHNOLOGY.
Cr. arr.
Prerequisite: A major or minor in food technology or dairy microbiology.

699. RESEARCH.
A. Dairy Technology.
B. Dairy Microbiology.
C. Dairy Chemistry.
D. Food Technology.

FORESTRY

Henry H. Webster, Ph.D., Head of Department

The Graduate Faculty

Members: D.W. Bensend, R.F. Finn, J.C. Gordon, H.S. McNabb, W.H. Scholtes, K.D. Ware, H.H. Webster

Associate Members: F.S. Hopkins, J.C. Meadows, Jr., D.R. Prestemon, G.W. Thomson, D.R. Yoesting

The department offers work for the degree Master of Science with majors in forest economics, forest management, forest mensuration, forest biology, and wood technology; the degree Master of Forestry with major in forestry, and the degree Doctor of Philosophy with majors in forest economics, forest mensuration, forest biology, and wood science.

Forestry minors are available to students taking major work in other departments. Study in the area of water resources is offered under a cooperative arrangement between the Department of Forestry and the departments of Agricultural Engineering, Agronomy, Bacteriology, Botany and Plant Pathology, Civil Engineering, Economics, Geology, and Zoology and Entomology.

Students desiring to major in this department should present forestry credits substantially equivalent to those required of undergraduate students in this institution.

There are no uniform language requirements for graduate study in forestry. No foreign language is required for the degree Master of Forestry. Foreign language requirements, if any, for the degree Master of Science and the Doctor of Philosophy are prescribed by the student's advisory committee in accord with his particular objectives and needs.

COURSES FOR GRADUATE STUDENTS, minor only

301. FOREST BIOLOGY.
(3-0) Cr. 3. W.
Prerequisite: 201, Bot. 256, 310, credit or classification in Agron. 357.
Effects of genetic and environmental factors on tree processes underlying forest tree production.

302. FOREST VEGETATION MANIPULATION.
(3-0) Cr. 3. S.
Prerequisite: 301.
The manipulation of forest vegetation in relation to ecological principles. Two one-day field trips.

380. WOOD TECHNOLOGY.
(3-6) Cr. 5. F.W.
Prerequisite: Biol. 101.
Anatomy, macroscopic indentification, and introduction to chemical and physical properties of wood as related to processing.

386. WOOD LIQUID RELATIONS.
(3-3) Cr. 4. F.
Prerequisite: 380; Chem. 231 or equivalent.
Cell wall structure; wood in relation to moisture; specific gravity; seasoning; protection of wood from insects and decay; fire retardent and stabilizing treatments.

397. FOREST REGULATION AND OPERATIONS.
(3-0) Cr. 3. S.
Prerequisite: 241, 301.
Principles of organizing, regulating, and administering forest lands in conjunction with commercial harvest and multiple-use goals for both private and public ownership.

400. FOREST CONSERVATION.
(3-0 or 3) Cr. 3 or 4. F.
Prerequisite: Biol. 101.
Not open to forestry students. Development of forest conservation, national, state, and private. Forests in relation to human needs. Forestry as related to other conservation work. Laboratory designed for students interested in farm forestry.

407. FOREST INFLUENCES.
(3-0) Cr. 3. W.
Prerequisite: 302.
Influence of forests on climate, soil, water yield, and soil erosion. Water yield and soil erosion control.

442. DYNAMICS OF FOREST STANDS.
(2-3) Cr. 3. W.
Prerequisite: 241.
Measurement of growth of forests. Models for quantifying stand structure and dynamics. Prediction of future structure, growth, and yield.

444. FOREST RESOURCE SURVEYS.
(4-0) Cr. 4. Alt. S, offered 1973.
Prerequisite: Stat. 104.
Methods for inventorying various forest resources and uses including range, water, and recreational resources. Estimating models and sampling schemes for providing estimates necessary to manage these resources within forestry context.

445. FOREST PHOTOGRAMMETRY AND PHOTO-INTERPRETATION.
(2-6) Cr. 4. F.
Prerequisite: 241, C.E. 201.
Use of aerial photographs in forest management. Measurement of land, trees, and timber stands on aerial photographs. Preparation of type and planimetric maps from photography. Principles of remote sensing. Forest resource management students only.

447. GENERAL PHOTOGRAMMETRY AND PHOTO-INTERPRETATION.
(2-2) Cr. 3. W.
Use of aerial and terrestrial photographs in resource management and research. Techniques of measurement, cartographic methods and interpretation applicable to controlled photographs.

451. MANAGEMENT OF FOREST RESOURCES: ECONOMICS AND MANAGEMENT.
(2-3) Cr. 3. S.
Prerequisite: 241, Econ. 242.
Economic factors and analytical methods influencing decisions by forest resource agencies and firms. Marketing of services and products provided by such agencies and firms; influence of population, income, and related economic and social factors.

452. MANAGEMENT OF FOREST RESOURCES: QUANTITATIVE ANALYSIS.
(3-3) Cr. 4. F.
Prerequisite: 241, Econ. 242, C.S. 201.
Methods for rigorously identifying and specifying problems involved in management, protection, and use of forest resources. Application of mathematical and statistical models in solving these managerial problems. Design and collection of information for use in these models.

453. MANAGEMENT OF FOREST RESOURCES: POLICY AND ADMINISTRATION.
(3-0) Cr. 3. W.
Prerequisite: 452, Pol.S. 215.
Analysis of the political, institutional, and administrative processes involved in the formulation of public and private policy concerning major forest resource issues.

454. MANAGEMENT OF FOREST RESOURCES: INTEGRATED CASE STUDIES.
(1-4) Cr. 3. S.
Prerequisite: 453.
Organizing and administration of major forest resources. Emphasis on case studies to illustrate methods of synthesizing the economic, mathematical, biological, political, and administrative principles discussed in preceding courses.

460. FOREST RECREATION.
(3-0) Cr. 3. W.
Prerequisite: 451 or Econ. 242.
Study of forest recreation in the United States. Relationship between forest recreation benefits and forest practices. Recreation policies and programs of public and private forest owners. Planning for recreation in forest management. Current problems and issues.

481. CHEMICAL PROCESSING OF WOOD.
(3-3) Cr. 4. Alt. W, offered 1972.
Prerequisite: 380; 386 recommended.
Chemical processing of cellulose-derived products; carbonization; destructive distillation; hydrolysis.

484. PROPERTIES OF WOOD.
(3-9) Cr. 3. Alt. SS, offered 1972.
Prerequisite: I.Ed. 205.
Structure and identification of wood; storage and handling of lumber; seasoning and other defects in lumber; machining and preparation of wood for gluing; woodworking glues. Not open to forestry majors.

485. WOOD COMPOSITE PRODUCTS.
(3-3) Cr. 4. Alt. S, offered 1972.
Prerequisite: 386, one course in organic chemistry.
Principles of adhesion, chemistry of wood adhesives, production of laminated wood, plywood, particle board and fiberboard products. A weekly seminar on the properties of materials other than wood and a field inspection trip.

487. MECHANICAL PROCESSING OF WOOD.
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: 380.
Mechanical processing: sawing, planing, sanding, chipping, and defiberization. Use of wood in structures.

488. PHYSICAL PROPERTIES OF WOOD.
(2-3) Cr. 3. Alt. S, offered 1973.
Prerequisite: 380; Phys. 111 or equivalent.
Wood in relation to heat, light, sound, and electricity. Introduction to wood mechanics.

489. WOOD PRODUCTS SEMINAR.
(0-2) Cr. 1. S.
Application of the principles of wood science to current industrial problems; detailed analysis of current events in the industry. Student presentation involved.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

504. APPLIED FOREST BIOLOGY.
(3-0) Cr. 3. Alt. S, offered 1973.
Prerequisite: 302.
Detailed analysis of the practice of silviculture in relation to silvical principles.

543. FOREST MENSURATION.
(3-0) Cr. 3. Alt. W, offered 1973.
Prerequisite: 442.
Estimation of current stand volume and of stand growth. Selection of variables for volume and yield tables. Applications of sampling methods to forest resource surveys.

570. ECONOMICS OF FOREST PRODUCTION.
(2-2) Cr. 3. Alt. F, offered 1971.
Prerequisite: 451, Econ. 308.
Economic analysis of production alternatives in forestry firms. Critical analysis of related research.

580. CHEMISTRY OF WOOD.
(3-0) Cr. 3. Alt. W, offered 1973.
Prerequisite: 481, Chem. 334.
Chemical composition of wood; chemical reactions of wood components; techniques for characterizing wood components.

583. RHEOLOGY OF WOOD.
(3-0) Cr. 3. Alt. W, offered 1972.
Prerequisite: 488, Math. 213.
Viscoelastic behavior of wood; time dependency of response to static, quasi-static, and dynamic stimuli. Nondestructive methods of evaluating mechanical properties of wood products.

587. ADVANCED TOPICS IN WOOD SCIENCE.
(3-0) Cr. 3. Alt. W, offered 1972.
Prerequisite: 380.
Recent contributions of research and technology to product development. Areas of emphasis in basic and applied research.

590. SPECIAL TOPICS.
Cr. 2 to 5 each time elected.
Prerequisite: Fifteen credits of acceptable graduate work, permission of instructor.
A. Silviculture.
B. Wood Science.
C. Forest Economics.
D. Forest Management.
E. Range Management.
F. Forest Mensuration and Photogrammetry.

594. ADVANCED FOREST MANAGEMENT.
(3-0) Cr. 3. Alt. F, offered 1972.
Prerequisite: 397.
A seminar approach to the critical analysis of forest management problems as exemplified in public and private forestry.

COURSES FOR GRADUATE STUDENTS, major or minor

601. RESEARCH METHODS IN FORESTRY.
(2-2) Cr. 3. Alt. W, offered 1973.
Scientific method; hypothesis formulation and testing; project and study planning; preparation and critical analysis of study plans. Communication of research results. Institutional factors in research.

602. ADVANCED FOREST BIOLOGY.
(3-0) Cr. 3. Alt. W, offered 1972.
Prerequisite: 302.
Detailed analysis of tree processes underlying forest tree production in relation to genetic and environmental factors.

645. ADVANCED FOREST MENSURATION.
(4-0) Cr. 4. Alt. S, offered 1972.
Prerequisite: 543, Stat. 401, 402, 421.
Theory and application of statistical and mathematical methods to forest measurement. Quantification problems in stand structure and growth. Sampling methods for forest inventory and estimation of past and future growth. Recent developments in forest mensuration.

670. RESOURCE ALLOCATION IN FORESTRY.
(Econ. 670) (2-2) Cr. 3. Alt. S, offered 1972.
Prerequisite: 451, Econ. 308.
Critical examination of public and private forest-related problems, forestry programs designed to solve these problems, and related research.

688. FORMATION OF WOOD.
(3-0) Cr. 3. Alt. W, offered 1972.
Prerequisite: 380.
Structure of the cell wall in woody plants. Measures of wood quality; environment as related to quality. Structure as related to the physical properties of wood.

699. RESEARCH.
Cr. 1 to 11.
A. Silviculture.
B. Wood Science.
C. Forest Economics.
D. Forest Management.
E. Range Management.
F. Forest Mensuration and Photogrammetry.

GENERAL SCIENCE

Oscar E. Tauber, Ph.D., Professor in Charge

The degree Master of Science with major in general science is available to graduate students who want or need a more diversified course of study than that generally permitted students who specialize in a single subject. Those who elect this program are allowed to take courses in three different subjects, each subject contributing approximately one-third of the required 45 credits toward the degree. The courses which may be used for credit toward this degree are those listed in this catalog for graduate credit. Both thesis and nonthesis options are available for the Master of Science degree. A written report, based on field, laboratory or library research, is required for students electing the nonthesis option.

The program has been most useful to those who wish to improve their subject matter competence in teaching. Students who wish to qualify for this degree should consult the program chairman as soon as possible so that the student's advisory committee may be appointed.

COURSES FOR GRADUATE STUDENTS, minor only

D.St. 480. SPECIAL PREPARATION IN SUBJECT MATTER FOR ELEMENTARY AND SECONDARY TEACHERS.
Cr. arr. Maximum of 12 credits in each area listed below:
A. Social Studies.
B. Physical Sciences.
C. Mathematics.
D. Biological Sciences.
E. English and Literature.
F. Physical Education for Men.
G. Foreign Languages.
H. Speech.
I. Journalism.
J. Earth Science.
K. Music.

GENETICS

William J. Welshons, Ph.D., Head of Department

The Graduate Faculty

Members: W.F. Hollander, J.D. Imsande, W.J. Miller, P.A. Peterson, E. Pollak, D.S. Robertson, K. Sadanaga, W.J. Welshons

Associate Member: A.G. Atherly

The department offers work for the degrees Master of Science and Doctor of Philosophy with a major in genetics. Within the major the student may specialize in *Drosophila,* maize, oat, mouse, immunological, microbial, biochemical, and developmental genetics. Minor work is offered to students taking majors in other departments.

No foreign language is required of candidates for the degree Master of Science. Candidates for the degree Doctor of Philosophy are required to pass the E.T.S. examination for two foreign languages with a score of 400 or better.

Prerequisite to major work is the completion of a thorough undergraduate curriculum in a biological science, or in a physical science or in agriculture with evidence of excellent scholarship and aptitude for scientific research.

Students taking major work in genetics may take minor work in agronomy, animal science, bacteriology, biochemistry, botany, horticulture, mathematics, statistics, veterinary medicine or zoology.

Major and minor work in the area of cell biology is offered under a cooperative arrangement with the departments of Bacteriology, Biochemistry and Biophysics, Botany and Plant Pathology, Genetics, and Zoology and Entomology.

COURSES FOR GRADUATE STUDENTS, minor only

401. **INTERMEDIATE GENETICS.**
(3-0) Cr. 3. F.
Prerequisite: 301.
Fundamental methods and concepts in genetics: chromosome mapping, gene structure, elementary mathematical genetics, polyploidy, and meiotic analysis.

460. **INTRODUCTION TO MATHEMATICAL GENETICS.**
(3-0) Cr. 3. S.
Prerequisite: 350 or 401; knowledge of elementary algebra. Pollak.
Elementary probability and its application to Mendelian, population, and quantitative genetics.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

536, 537. **GENETIC STATISTICS.**
(Stat. 536, 537) See Statistics.

590. **SPECIAL TOPICS.**
(0-3 to 9) Cr. arr.
Prerequisite: 305, 401.

COURSES FOR GRADUATE STUDENTS, major or minor

605. **CYTOGENETICS.**
(Bot. 605) (3-0) Cr. 3. W.
Prerequisite: 350 or 401; C.Bio. 527. Robertson.
Studies of cytology and genetics in plants and animals with emphasis on crossing over and changes in chromosome structure and number.

615. **LABORATORY IN CYTOGENETICS.**
(0-6) Cr. 2. S.
Prerequisite: 605. Sadanaga.
Laboratory methods and techniques for cytogenetical research, with emphasis on plants.

620. **MOLECULAR GENETICS.**
(Bact. 620, Im.Bio. 620) (3-0) Cr. 3. S.
Prerequisite: 350 or 401.
Structure, mutation, and recombination of genes considered at the molecular level; biosynthetic pathways and gene interaction; the gentic code, protein synthesis, and regulatory mechanisms.

621. **BACTERIAL GENETICS.**
(Bact. 621) See Bacteriology.

630. **ADVANCED PLANT GENETICS.**
(3-0) Cr. 3. S.
Prerequisite: 350 or 401. Robertson.
Genetic analysis of plants including evolution, biochemical genetics, translation of genetic information, cytoplasmic inheritance, incompatibility systems, alterations of meiosis, and sex determination.

635. **ANIMAL GENETICS.**
(3-6) Cr. 5. W.
Prerequisite: 305; 350 or 401. Hollander.
Analytical procedures by means of markers, with special regard to *Drosophila*; surveys of the status of genetic analysis in animals, especially domesticated species.

640. GENES AND MUTATIONS.
(3-0) Cr. 3. Alt. W, offered 1972.
Prerequisite: 350 or 401. Peterson.
Analysis of selected genes and mutations in microbial and higher forms. Topics include genetic fine structure, rates of mutation, units of recombination, controlling elements, and evolutionary aspects of mutation.

646. IMMUNOGENETICS.
(Im.Bio. 646) (3-0) Cr. 3. Alt. F, offered 1973.
Prerequisite: 350 or 401; Bact. 575 or consent of instructor. Miller.
Application of immunological principles to genetics; analytical procedures of blood typing; individual and species variation.

650. POPULATION GENETICS.
(An.S. 650) See Animal Science.

690. SEMINAR.
Cr. 1. F.W.S.

698. SEMINAR IN CELL BIOLOGY.
(C.Bio. 698) See Cell Biology.

699. RESEARCH.

HISTORY

Walter Rundell, Jr., Ph.D., Chairman of Department

The Graduate Faculty

Members: L.J. Apt, R.N. Kottman, W. Rundell, Jr., H.I. Sharlin

Associate Members: A.A. Bennett, H. Cravens, J.M. Dobson, C.W. Keller, G.T. McJimsey, K.G. Madison, G.O. Nichols, W.S. Osborn, J.W. Whitaker, A.F. Wilt, P.B. Zaring

The department offers work for the degree Master of Arts with majors in history and in history of science and technology. Both programs are designed to enable a graduate to teach in high schools and junior colleges, enter government service, or pursue further study.

Students may elect either a nonthesis program or a thesis program. Those choosing a nonthesis program will take oral comprehensive examinations over two survey fields, such as United States history, western civilization, or the like. Those writing a thesis will be examined orally on the thesis and its related historical milieu.

COURSES FOR GRADUATE STUDENTS, minor only

***400A, 400B, 400C. ANCIENT HISTORY: PRECLASSICAL MEDITERRANEAN WORLD.**
(3-0) Cr. 3 each. Alt. Yr, offered 1971.
Prerequisite: Nine credits in history.
400A: Primary Civilizations: Mesopotamia, Egypt, Greece from the neolithic revolution to 1200 B.C. 400B: The era of Small Powers—1200-800 B.C.; Hebrews and their neighbors; Greece in the Age of Heroes. 400C: The final unification of Ancient Near East—800-333 B.C.; Assyrian, neo-Babylonian, Egyptian, and Persian empires; influence of Near East on Greece 800-600 B.C.

***403A, 403B, 403C. ANCIENT HISTORY: THE CLASSICAL WORLD.**
(3-0) Cr. 3 each. Alt. Yr, offered 1972.
Prerequisite: Nine credits in history.
403A: Classical Greece 600-338 B.C. 403B: Hellenistic World; Alexander's conquests, his successors; rise of Rome, conquest of the Mediterranean world to 30 B.C. 403C: The Roman Empire from Augustus to Diocletian and Constantine, 30 B.C. - 312 A.D.

***404A, 404B, 404C. HISTORY OF MEDIEVAL WESTERN EUROPE.**
(3-0) Cr. 3 each. Yr.
Prerequisite: Nine credits in history.
Development of political, economic, and social institutions. 404A: Early Middle Ages; 404B: High Middle Ages; 404C: Late Middle Ages.

407. THE ITALIAN RENAISSANCE.
(3-0) Cr. 3. W.
Prerequisite: Nine credits in history.
Secularization of society, city-states, economic growth and decline, new intellectual interests, historiography.

408. EUROPE: 1500 to 1648 (REFORMATION).
(3-0) Cr. 3. S.
Prerequisite: Nine credits in history.
The Northern Renaissance; emergence of religious dissent; Protestant revolt; triumph and tragedy of Spain; victory of Calvinism; reaction and reform within Roman Catholicism; religious wars and the emergence of France.

***410A, 410B, 410C. CONTEMPORARY EUROPE.**
(3-0) Cr. 3 each. Yr.
Prerequisite: Nine credits in history.
410A: The Age of European pre-eminence. 1871-1914; 410B: The Great War and after; 410C: Europe since 1939.

***411A, 411B. ECONOMIC HISTORY OF MODERN EUROPE.**
(3-0) Cr. 3 each. 411A: F; 411B: W.
Prerequisite: Nine credits in history.
411A: Economic and political revolutions 1750-1900; English and continental heritage from medieval Europe; commercial, industrial, agricultural revolutions; economic institutions and reforms; capitalism, competition, imperialism. 411B: Rise of continental industry; changes in labor, transportation, markets, reparations, revolutions, reconstruction, competition, depression, and war.

*416A, 416B, 416C. HISTORY OF RUSSIA.
(3-0) Cr. 3 each. Yr.
Prerequisite: Nine credits in history.
416A: Kievan and Muscovite Russia, 850-1700. Origins of Russian state; Mongol invasion; rise of Moscow. 416B: Imperial Russia, 1700-1917. Peter the Great and his successors; impact of the West; eve of the Revolution. 416C: Soviet Union, 1917 to present. Revolution and Russian society; emergence of the USSR as a world power.

*421A, 421B. TUDOR-STUART ENGLAND.
(3-0) Cr. 3 each. 421A: F; 421B: W.
Prerequisite: Nine credits in history.
421A: Tudor England, 1485-1603. Political, economic, and cultural development of 16th century England. 421B: Stuart England, 1603-1714. Emphasis on the constitutional and economic problems in the development of the modern state.

*430A, 430B, 430C. HISTORY OF SCIENCE.
(3-0) Cr. 3 each. Yr.
Prerequisite: Nine credits in history.
430A: Prehistory to Copernicus: Development of natural science in Babylonia, Egypt, China, India; Greek science; medieval and Arabic science. 430B: Beginnings of modern science: the 16th, 17th, and 18th century revolutions in astronomy, mechanics, biology, and chemistry. Rise of scientific societies and the experimental method. 430C: Modern science: Development of physics, chemistry, and biology in the 19th and 20th centuries.

431A, 431B. HISTORY OF ENGINEERING.
See History of Science and Technology.

433. SCIENCE AND MODERN THOUGHT FROM 1500 TO PRESENT.
See History of Science and Technology.

443. MODERN JAPANESE HISTORY.
(3-0) Cr. 3. S.
Prerequisite: Nine credits in history.
Political, cultural, social, and economic history of Japan, particularly since 1853.

*462A, 462B, 462C. COLONIAL AMERICA.
(3-0) Cr. 3 each. Yr.
Prerequisite: Nine credits in history.
Expansion of Europe and colonial foundations. Economic, political, and social development to 1776.

464. THE JACKSONIAN MOVEMENT.
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: Nine credits in history.
Origins, development, and significance of Jacksonian democracy in determining and revealing the nature of American economic, social, and political mores and institutions.

466. SECTIONAL CONFLICT AND THE CIVIL WAR.
(3-0) Cr. 3. F.
Prerequisite: Nine credits in history.
Economic, social, political, and psychological conflicts which undermined the democratic process and drove the United States to Civil War.

468A. THE RECONSTRUCTION ERA 1865-1877.
(3-0) Cr. 3. W.
Prerequisite: Nine credits in history.
Major social and political features of the United States following the Civil War. The decision to reconstruct the South. Accomplishments and failures of reconstruction.

*469A, 469B, 469C. TWENTIETH CENTURY AMERICA.
(3-0) Cr. 3 each. Yr.
Prerequisite: Nine credits in history.
Major political, economic, and social developments of the nation from advent of Progressivism to present; emphasis on growth of the government as a regenerative force in American society. 469A: Progressive Movement, home front during WWI, red scare, and post-war reaction. 469B: New economic era of the 1920's, depression, Hoover administration, the New Deal. 469C: Wartime America, Fair Deal, Modern Republicanism, the New Frontier, and the Great Society.

471. SOCIAL AND INTELLECTUAL HISTORY OF THE UNITED STATES.
(3-0) Cr. 3. S.
Prerequisite: Nine credits in history.
Development of social and intellectual movements, institutions, and leaders.

*474A, 474B. THE WESTWARD MOVEMENT AND FRONTIER DEVELOPMENT.
(3-0) Cr. 3 each. 474A: F; 474B: W.
Prerequisite: Nine credits in history.
474A: Occupation, distribution, and political organization of the public domain; Indian-white relations; 474B: Economic exploitation of the public domain (fur trade, mining, lumbering, range cattle industry, farming), social adjustments (law and order, religion, education, and culture).

*477A, 477B, 477C. HISTORY OF THE UNITED STATES FOREIGN POLICY.
(3-0) Cr. 3 each. Yr.
Prerequisite: Nine credits in history.
Diplomatic history emphasizing penetration of American influence in those areas where the United States has exercised leadership. 477A: Diplomacy from the American Revolution to post-Civil War expansionism. 477B: America's rise as a world power from the Spanish American War to World War I; peace making. 477C: Diplomacy of 1920's to present.

478. U.S.-SOVIET RELATIONS.
(3-0) Cr. 3. F.
Prerequisite: Nine credits in history.
Diplomatic issues between the two states from the inception of the Soviet Union to the present; emphasis on period of nonrecognition and American intervention in Russian Civil War, and origins of the Cold War.

*479A, 479B. INTER-AMERICAN RELATIONS.
(3-0) Cr. 3 each. 479A: F; 479B: W.
Prerequisite: Nine credits in history.
Relations between the United States and other nations of the western hemisphere; rise of United States influence in this area. 479A: 19th century. Evolution of Monroe Doctrine. Pan-Americanism, and economic penetration by the United States. 479B: 20th century. United States hegemony in the Caribbean, multilateralization of the Monroe Doctrine, and hemispheric solidarity.

490. SPECIAL PROBLEMS.
Cr. 1 to 3 each time taken.
Prerequisite: Permission of department chairman; 9 credits in history.
Reading and reports on problems selected in conference with each student.

*Any course listed in the following history sequences may be taken independently: 400A, 400B, 400C; 403A, 403B, 403C; 404A, 404B, 404C; 410A, 410B, 410C; 411A, 411B; 416A, 416B, 416C; 421A, 421B; 430A, 430B, 430C; 462A, 462B, 462C; 469A, 469B, 469C; 474A, 474B; 477A, 477B, 477C; 479A, 479B.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

512A, 512B. EUROPEAN INTELLECTUAL HISTORY.
(3-0) Cr. 3 each. 512A: Alt. W; 512B: Alt. S, offered 1973.
Prerequisite: Nine credits in history.
512A: European ideas from the Renaissance through the Enlightenment. 512B: From the Enlightenment to the present.

515. HISTORY OF TECHNOLOGY IN THE UNITED STATES.
See History of Science and Technology.

517A, 517B. HISTORY OF MODERN GERMANY.
(3-0) Cr. 3 each. 517A: Alt. W; 517B: Alt. S, offered 1972.
Prerequisite: Nine credits in history.
517A: Central Europe in the 17th and 18th centuries. 517B: Economic, political, and social developments in 19th- and 20th-century Germany.

541. PHILOSOPHY OF HISTORY.
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: Nine credits in history.
Concepts of causality, time, determinism, nature, and generalization.

561. TECHNOLOGY IN DEVELOPING COUNTRIES.
See History of Science and Technology.

590. SPECIAL TOPICS.
Cr. 1 to 3 each time taken.
Prerequisite: Permission of instructor.

591A, 591B, 591C. SEMINAR IN HISTORY OF SCIENCE.
See History of Science and Technology.

592. SEMINAR IN EAST ASIAN HISTORY.
(3-0) Cr. 3. S.
Prerequisite: Permission of instructor.
Topics vary each time offered.

593. SEMINAR IN AMERICAN HISTORY.
(3-0) Cr. 3 each time taken.
Prerequisite: Permission of instructor.
Topics vary each time offered.
A. Colonial Period.
C. Jacksonian America.
D. Civil War and Reconstruction.
E. Twentieth Century.
F. Constitutional.
G. Diplomatic.
H. Economic.
I. American Frontier.
J. Intellectual.

594. SEMINAR IN EUROPEAN HISTORY.
(3-0) Cr. 3 each time taken.
Prerequisite: Permission of instructor.
Topics vary each time offered.
A. Ancient.
B. Medieval.
C. English.
D. Modern.
E. Diplomatic.
F. Economic.
G. German.
H. French.
I. Russian.
J. Intellectual.

596A, 596B. HISTORICAL METHODS.
(3-0) Cr. 3 each. 596A: F; 596B: W.
Prerequisite: 596A: Permission of instructor; 596B: 596A.
Original sources, bibliography, criticism of evidence, form.

COURSE FOR GRADUATE STUDENTS, major or minor

699. RESEARCH.

HISTORY OF SCIENCE AND TECHNOLOGY

Harold I. Sharlin, Ph.D., Professor in Charge

Graduate study for the degree Master of Arts with a major in the history of science and technology was developed jointly by the College of Engineering and the Department of History and is administered by the Department of History. Minor work is offered to students taking major work in other disciplines.

Prerequisite to major graduate work in the history of science and technology is the completion of at least 18 credits in history and 18 credits in science and/or engineering. See *History*.

COURSES FOR GRADUATE STUDENTS, minor only

Hist. 431A, 431B. HISTORY OF ENGINEERING. (Engr. 431A, 431B) (3-0) Cr. 3 each. 431A: F.W.; 431B:W.S.

431A: The process of innovation. Origins of early inventions. Technical development in the East and the West. Engineering in Mediterranean civilizations. Technical advances through the Rennaissance. 431B: Emergence of modern engineering after 1700. Influences of science, society and resources upon technological development. Rise of professionalism; place of engineer in today's culture.

Hist. 433. SCIENCE AND MODERN THOUGHT FROM 1500 TO PRESENT.
(Engr. 433) (3-0) Cr. 3. S.
Prerequisite: Nine credits in history.
Interaction of scientific with social, political and economic thought.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

Hist. 515. HISTORY OF TECHNOLOGY IN THE UNITED STATES.
(Engr. 515) (3-0) Cr. 3. S.
Prerequisite: 431B.
Transfer of technology and science from Europe; U.S. innovations; the "American system" of manufacture and mass-production; heavy industry; scientific management.

Hist. 561. TECHNOLOGY IN DEVELOPING COUNTRIES.
(Engr. 561) (3-0) Cr. 3. F.
Prerequisite: 431B.
Historical review of technological development of developing countries, with emphasis upon United Kingdom, U.S. and Japan; factors affecting rate of development, analysis and comparison of current technological status of selected cultures in America, Africa and Asia.

Hist. 590. SPECIAL TOPICS IN THE HISTORY OF TECHNOLOGY.
(Engr. 590) Cr. 2 to 5.
Prerequisite: Nine credits in history of technology.

Hist. 591A, 591B, 591C. SEMINAR IN HISTORY OF SCIENCE.
(Engr. 591) (3-0) Cr. 3 each. Yr.
Prerequisite: Permission of instructor.
591A: Creativity in sciences and humanities. Comparison of careers in these fields. Reasons for choice of career and how originality is expressed. 591B: Relation between science and technology. Effects of technological change on scientific thought and new theories on technology. Prehistory to present. 591C: History of science and technology.

COURSE FOR GRADUATE STUDENTS, major or minor

Hist. 699. RESEARCH.

HOME ECONOMICS

Helen LeBaron Hilton, Ph.D., Dean of Home Economics
Julia Faltinson Anderson, M.S., Associate Dean
Marguerite Scruggs, Ph.D., Assistant Dean for Graduate Study and Research

COURSES FOR GRADUATE STUDENTS, major or minor

540. GRADUATE SEMINAR.
Cr. arr. F.W.S.
A. Interdepartmental.
B. Field Trip.

590. SPECIAL TOPICS.
Cr. arr.

HOME ECONOMICS EDUCATION

Ruth P. Hughes, Ph.D., Head of Department

The Graduate Faculty

Members: R.P. Hughes, L.L. Inman, E.L. Kohlmann, M. Scruggs

Associate Members: I. Beavers, A.M. Fanslow, V.F. Thomas, K.W. Zimmerman

The department offers work for the degrees Master of Science and Doctor of Philosophy with major in home economics education and minor work to students taking major work in other departments.

A student expecting to do major work should have fundamental knowledge of psychology, education, sociology, and home economics. The exact requirements will depend upon the field of work the student expects to pursue.

A foreign language is not required for the degrees Master of Science or Doctor of Philosophy. Statistics is included in the program of study for both degrees with a higher level of competence required for the degree Doctor of Philosophy.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

500. SHORT COURSE.
Cr. arr. SS.
Prerequisite: Permission of instructor.
A. Adult Education.
B. Evaluation.
C. Curriculum.
D. Program Planning.
E. Supervision.
F. Teacher Education.

505. WORKSHOP.
Cr. 1 to 5. SS.
Prerequisite: Permission of instructor.
Concentrated group study of problems in fields of home economics education. Sections offered will vary from year to year.
A. Adult Education. **Beavers.**
B. Evaluation. **Fanslow.**
C. Home Economics Curriculum. **Kohlmann.**
D. Supervision and Administration. **Thomas.**
E. Special.

507. TRENDS IN TEACHING HOME ECONOMICS.
(2 or 3-0) Cr. 2 or 3. F.SS.
Prerequisite: Teaching experience.
Economic, political, and social changes affecting the home economics curriculum; the application of new knowledge and educational theory to curriculum planning; developments in organization, media, and methods for teaching home economics.

508. ADULT EDUCATION IN HOME ECONOMICS.
(3-0) Cr. 3. W.SS.
Prerequisite: Nine credits in home economics education and or education.
Contribution of home economics subject matter to adult education for home and family living, occupational training, and personal enrichment; methods of promoting, organizing, teaching, and evaluating adult programs; structure and goals of organizations and agencies related to home economics adult-education programs.

509. TEACHING FOR HOME ECONOMICS RELATED WAGE-EARNING OCCUPATIONS.
(1-2) Cr. 2. S.SS.
Prerequisite: Nine credits in home economics education and or education.
Planning and conducting courses for training adolescents and adults in home economics related wage-earning occupations. Planning and arranging business and industrial experiences for job trainees.

590. SPECIAL TOPICS.
Cr. arr.
Prerequisite: 406.
A. Adult Education.
B. Administration.
C. Curriculum.
D. Evaluation.
E. Extension.
F. Supervision.
G. General.
I. Teacher Education.
J. Research Methodology.

COURSES FOR GRADUATE STUDENTS, major or minor

605. HOME ECONOMICS CURRICULA.
(3-0) Cr. 3. W.SS.
Prerequisite: Fifteen credits in education and teaching experience. Kohlmann.
Curriculum building applied particularly in home economics for secondary schools and colleges.

606. EDUCATIONAL LEADERSHIP AND SUPERVISION IN HOME ECONOMICS.
(3-0) Cr. 3. S.SS.
Prerequisite: Five credits in graduate courses in home economics education. Thomas.
Objectives, principles, and functions of supervision in student teaching, school systems, and state departments of education.

609. ADULT EDUCATION IN FAMILY LIFE.
(3-0) Cr. 3. W.SS.
Prerequisite: 508 or experience in adult education. Beavers.
Philosophy of family life education for adults. Interests and needs of various age and social groups. Methods and materials effective in group work and in educational media such as radio and television. Findings of research in the field of adult and family life education.

610. SEMINAR.
Cr. 1 each quarter. W.S.SS.

611. DESIGN OF RESEARCH IN HOME ECONOMICS EDUCATION.
(3-0) Cr. 3. F.SS.
Prerequisite: Credit or classification in Educ. 552 or Stat. 401. Fanslow.
Exploratory, descriptive, quasi-experimental, experimental, and historic research designs. Needed research in home economics education. Planning a research study. Evaluation of research reports.

612. EVALUATION IN HOME ECONOMICS.
(3-0) Cr. 3. S.SS.
Prerequisite: Twelve credits in education.
Selection and construction of evaluation devices. Their use and interpretation in home economics programs.

699. RESEARCH.

HORTICULTURE

Ervin L. Denisen, Ph.D., Chairman of Department

The Graduate Faculty

Members: E.L. Denisen, C.F. Hodges, J.D. Kelley, J.P. Mahlstede, J.C. Schilletter, E.C. Volz

Associate Members: R.J. Bauske, G.J. Buck, C.W. Heuser, M.L. Robbins, C.H. Sherwood, J.L. Weigle

The department offers work for the degrees Master of Science and Doctor of Philosophy with major in horticulture, and minor work for students taking major work in other depart-

ments. Within the major the student may specialize in fruit crops, vegetable crops, floriculture, nursery crops, ornamentals, and turfgrass.

Prerequisite to major graduate work is the completion of courses covering the general field of horticulture or botany and the underlying sciences.

Students with major interest in fruit crops, floriculture, vegetable crops, nursery crops, ornamentals, or turfgrass should present 15 credits of undergraduate work in horticulture, botany, landscape gardening, or agronomy. The student also should have a working knowledge of inorganic and organic chemistry, general botany, and soils equivalent to the requirements outlined in the general curriculum for horticultural students at this institution.

Students taking major work in horticulture usually will take minor work in agronomy, genetics, botany (physiology, pathology, cytology, or morphology), entomology, statistics, or chemistry.

There is no uniform foreign language requirement for either the degree Master of Science or Doctor of Philosophy.

COURSES FOR GRADUATE STUDENTS, minor only

413. TURFGRASS SCIENCE.
(Agron. 413) (3-0) Cr. 3. Alt. S, offered 1973.
Prerequisite: 314, Biol. 101, Bot. 107, 310.
The grass plant: structure, growth, and physiology in relation to the physical (soil, water, light, fertility) and biological (soil microorganisms and pathogens) environment.

422. ORCHARDING.
(2-2) Cr. 3. Alt. S, offered 1973.
Prerequisite: 321.
Propagation, planting, pruning, maintenance, physiology of growth, and storage of orchard crops.

446, 447. FLORICULTURAL SCIENCE.
(2-2) Cr. 3 each. 446: Alt. F, offered 1972; 447: Alt. W, offered 1973.
Prerequisite: 446: 154; 447: 446.
446: Culture and propagation of florist bench crops and potted plants. 447: Culture of tender bedding plants; marketing cut flowers; organization and management of greenhouse and retail store.

467. HORTICULTURAL TECHNOLOGY.
(3-0) Cr. 3. Alt. W, offered 1973.
Prerequisite: Bot. 310, Agron. 354, permission of instructor.
Application of new technology to the production and handling of horticultural crops, including current aspects of soil fertility, variety development, post-harvest physiology, and mechanization.

480. SYSTEMATIC HORTICULTURE I.
(2-2) Cr. 3. Alt. F, offered 1971.
Origin, identification, classification, description, and genetics of woody ornamental plants.

481. SYSTEMATIC HORTICULTURE II.
(2-2) Cr. 3. Alt. W, offered 1972.
Origin, identification, classification, description, and genetics of conservatory plants.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

501. HORTICULTURAL FOOD CROPS.
(2-2) Cr. 3. Alt. F, offered 1971.
Comparative classification of fruits and vegetables based upon physiological, morphological, and cytogenetical similarities and differences; their horticultural use as related to these factors.

514. HORTICULTURAL SCIENCE.
(3-0) Cr. 3. Alt. W, offered 1973.
Prerequisite: Three credits in plant physiology, Agron. 354, Stat. 101.
The physiological bases for horticultural techniques or practices and the effect of environment in modifying these techniques.

518. GENETICS AND BREEDING OF HORTICULTURAL PLANTS.
(3-0) Cr. 3. Alt. W, offered 1972.
Prerequisite: Gen. 301.
A study of genetic systems and breeding techniques or methods that are of particular value to the improvement of horticultural plants.

590. SPECIAL TOPICS.
Cr. arr.
Prerequisite: A major or minor in horticulture.

COURSES FOR GRADUATE STUDENTS, major or minor

604. GRADUATE SEMINAR.
Cr. 1 each time elected. F.W.S.

621. CURRENT TOPICS IN OLERICULTURE.
Cr. 2. Offered as arr.
Review and discussion of current literature and problems concerning the genetics, physiology, and culture of vegetables.

622. CURRENT TOPICS IN POMOLOGY.
Cr. 2. W.
Review and evaluation of current investigations on fruit breeding, physiology, mechanization, handling, and storage.

624. PHYSIOLOGY OF HORTICULTURAL PLANTS.
Cr. 3. Alt. S, offered 1972.
Prerequisite: Botany 513, permission of instructor.
Application of plant physiology to the problems of sexual and asexual propagation, dormancy, and fruit development.

699. RESEARCH.
Cr. 1 to 11.

HOUSING

Margaret I. Liston, Ph.D., Chairman, Advisory Committee

Advisory Committee: Thomas A. Barton, M.L.A.; Martin D. Gehner, M.Arch.; Clair B. Watson, M.F.A.

Work in housing is offered for the degrees Master of Architecture, Master of Landscape Architecture, Master of Arts, or Master of Science as appropriate in the following cooperating departments or major areas: Applied Art, Architecture, Family Environment, Landscape Architecture, or Town and Regional Planning.

A student majoring in housing will choose his major professor from the graduate faculty membership of the cooperating departments and will develop his program for study under the guidance of a committee nominated by the advisory committee and appointed by the dean of the Graduate College.

For administrative purposes the student will be considered as majoring in the department of the major professor and will be listed as having the degree in that department with emphasis on housing.

Programs in housing should be planned to include courses from several of the following departments:

Applied Art: 490E[1], 590E, 699.

Architecture: 361[1], 362[1], 363[1], 514, 515, 516, 543, 590, 611, 612, 613.

Economics: 307[1], 308[1], 405[1], 409[1], 434[1], 461[1], 462[1], 510, 565, 566.

Family Environment: 308[1], 340[1], 412[1], 415[1], 445[1], 446[1], 485[1], 488[1], 504, 521, 590B, 604B, 699B.

Landscape Architecture: 490[1], 590, 699. Urban Planning: 372[1], 380[1], 383[1], 395[1], 490[1], 492[1], 561, 562, 571, 590, 592, 699.

Sociology: 410[1], 445[1], 450[1], 464[1], 482[1], 483[1], 485[1], 585, 692.

Statistics: 401[1], 402[1], 411[1], 421[1].

[1] Graduate credit not available to majors in this department.

IMMUNOBIOLOGY

Merlin L. Kaeberle, D.V.M., Ph.D., Chairman, Advisory Committee

Advisory Committee: Wilmer J. Miller, Ph.D.; Loyd Y. Quinn, Ph.D.

Work is offered for the degrees Master of Science and Doctor of Philosophy with major in immunobiology under a cooperative arrangement with the departments of Agronomy, Animal Science, Bacteriology, Biochemistry and Biophysics, Botany and Plant Pathology, Food and Nutrition, Food Technology, Forestry, Genetics, Horticulture, Veterinary Clinical Sciences, Veterinary Microbiology and Preventive Medicine, Veterinary Pathology, and Zoology and Entomology. Facilities exist in several departments for fundamental research in such areas as immunogenetics, physiology of antibody formation, immunofluorescence microscopy, immunochemistry, immunocytology, immunopathology, immunoparasitology, microbial immunology, and serology.

A student majoring in immunobiology will choose a major professor from the graduate faculty membership of cooperating departments and will develop his program of study under the guidance of an advisory committee nominated by the administrative department head, ap-

proved by the immunobiology advisory committee and appointed by the dean of the Graduate College. For administrative purposes the student will be assigned to the department of his major professor.

Students desiring to do graduate work with a major in immunobiology should have a bachelor's degree or equivalent in one of the areas related to the cooperating departments listed above and should qualify for admission to one of these departments. A strong background in biological sciences is desirable, including work in immunology, genetics, and biochemistry. Students who do not have these prerequisites should plan to complete them in addition to the regular course requirements for the advanced degree.

Immunobiology majors should include in their program of study a core of courses chosen from those listed below and comprising the basic program in immunobiology. Formal courses in biochemistry and statistics are recommended. The following courses are also appropriate for inclusion in the program: Bact. 509, 601, 615, 645, 660, 678; B.& B. 574, 575; C.Bio. 527, 528; Gen. 605, 615; Stat. 411; Vet. Micr. 526, 625; Vet. Pth. 653; Zool. 529.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

520. **SEROLOGY.**
(V. Micr. 520) See Veterinary Microbiology.

575. **IMMUNOLOGY.**
(Bact. 575) See Bacteriology.

COURSES FOR GRADUATE STUDENTS, major or minor

620. **MOLECULAR GENETICS.**
(Gen. 620) See Genetics.

629. **MEDICAL IMMUNOLOGY.**
(V. Micr. 629) See Veterinary Microbiology.

646. **IMMUNOGENETICS.**
(Gen. 646) See Genetics.

675. **ADVANCED IMMUNOLOGY.**
(Bact. 675) See Bacteriology.

690. **SPECIAL TOPICS.**
Cr. arr. Offered on request with approval of advisory committee.
Prerequisite: Twelve credits in immunobiology; permission of instructor.
Experimental methods applied in subdisciplines of immunobiology:
A. Immunochemistry.
B. Immunocytology.
C. Immunogenetics.
D. Immunologic Disease.
E. Immunoparasitology.

695. **SEMINAR.**
(1-0) Cr. 1. F.S.
Prerequisite: Permission of instructor. Kaeberle.
Concepts and research in immunobiology.

INDUSTRIAL ADMINISTRATION

W.H. Thompson, Ph.D., Chairman of Department

The Graduate Faculty

Member: W.H. Thompson

Associate Members: C.P. Baumel, M. Zober

COURSES FOR GRADUATE STUDENTS, minor only

425. **FEDERAL INCOME TAX.**
(3-0) Cr. 3. F.W.S.SS.
Prerequisite: 371 or 384.
Development of federal income tax legislation and its application to individual and corporate taxpayers. Federal gift and estate taxes. Emphasis on transaction planning by individuals for tax minimization.

440. **INDUSTRIAL PURCHASING.**
(3-0) Cr. 3. F.
Prerequisite: 340.
The purchasing function, management, purchase of optimum quantity, standardization, quality control, store control, purchasing research, and computer applications.

443. MARKETING MANAGEMENT.
(3-0) Cr. 3. F.W.
Prerequisite: 340.
Marketing decisions with emphasis on pricing, advertising, personal selling, product development, and channels of distribution. Cases and computer game employed.

444. MARKETING RESEARCH.
(4-0) Cr. 4. W.S.
Prerequisite: 443.
Problem formation, research design, questionnaire construction, sampling and interviewing of consumers and businessmen. Marketing research techniques.

445. PRINCIPLES OF INVESTMENTS.
(4-0) Cr. 4. F.W.SS.
Prerequisite: 350.
Mechanics of investment and secondary capital markets. Individual and institutional investment in limited-income securities common stocks. Use of computer in portfolio selection. Also required is a dictated study of a business and the industry of which it is a part.

463. HIGHWAY TRANSPORTATION.
(3-0) Cr. 3. F.W.
Prerequisite: 360.
Analysis of resource allocation in the highway sector. Financing and development of highways. Managerial and economic aspects of motor transportation and its role in economic and social life.

464. BUSINESS LOGISTICS.
(4-0) Cr. 4. F.W.S.
Prerequisite: 460.
Management of flow of materials from the source of supply through processing to ultimate marketplace delivery. Design and application of methods for the solution of physical movement problems of business firms. Field trips.

467. PUBLIC UTILITIES.
(3-0) Cr. 3. F.S.
Prerequisite: Econ. 242.
Nature of the public utility concept. Theories of valuation and rate of return; plant operation and utilization; capital structures. Division of regulatory control between state and national government. Private and public ownership of utilities in the United States.

469. TRANSPORTATION SEMINAR.
(3-0) Cr. 3. S.
Prerequisite: 464.
Contemporary problems in the field of transportation.

470. SALES FORECASTING.
(3-0) Cr. 3. W.SS.
Prerequisite: 340 recommended, Stat. 127.
Time series, regression, exponential smoothing, cycle analysis, mathematical models, survey techniques, and nonmathematical methods; methods of calculating gross national product, including use of input-output tables.

480. COST ACCOUNTING.
(4-0) Cr. 4. F.W.SS.
Prerequisite: 385, or 384 and permission of instructor.
Product costing and control as they relate to job order, process, and standard-cost systems. Introduction to cost-volume-profit relationships, budgeting, and profit planning. Field trips.

481. ADVANCED COST ACCOUNTING.
(3-0) Cr. 3. S.
Prerequisite: 480.
Further development of product costing and control procedures: cost reports as an aid in managerial decision making, capital budgeting, distribution costs, direct costing, responsibility accounting, profit centers, and transfer pricing. Field trips.

490. SPECIAL PROBLEMS.
Cr. 1 to 3 each time taken.
Prerequisite: Permission of instructor.
A. Accounting.
B. Finance.
C. General Business.
D. Marketing.
E. Transportation.
F. Physical Distribution.
G. Law.

491. GENERAL INSURANCE.
(3-0) Cr. 3. F.S.SS.
Prerequisite: 365.
Risk and risk bearing as applied to individuals and business firms. Insurance and probability. Fundamentals of insurance contracts with special emphasis on life and health, with some attention given to automobile insurance.

INDUSTRIAL EDUCATION

William D. Wolansky, Ed.D., Professor in Charge

The Graduate Faculty

Member: W.D. Wolansky

Associate Members: L.L. Carver, G.A. Parks, L.C. Schwenk, A.M. Sherick, M.O. Wiener

Industrial education offers work for the degrees Master of Science, Master of Education, and Doctor of Philosophy in education with major in industrial education, and minor work for students taking major work in other departments. Within the industrial education major, a student may specialize in vocational-technical education or industrial arts.

Prerequisite to major graduate work is preparation substantively equivalent to the comple-

tion of the undergraduate curriculum in industrial education and adequate proof that the student ranks above average in scholastic ability and promise of professional competency.

There is no language requirement for the degrees Master of Science or Master of Education. A satisfactory reading knowledge of two languages selected from French, German, Russian, or Spanish is required of doctoral candidates. At the discretion of the student's advisory committee, the foreign language requirement may be met by: (1) demonstrating a satisfactory reading knowledge of two of the languages named; (2) demonstrating a significantly higher degree of competence in one of the named languages; (3) substituting two years of undergraduate study in the language with a B average for one of the above languages; or (4) substituting 9 quarter credits of graduate work in addition to the minimum Ph.D. requirements in approved areas for one language or 18 credits for two languages. Students whose native language is not English may substitute competence in English for one of the languages.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

501. **WOOD COMPOSITION MATERIALS.**
(1-5) Cr. 3. F. Alt. SS, offered 1973.
Prerequisite: 205 or permission of instructor.
Principles of small-scale production of particle board, hard board, and wood flour-molded products through hot and cold molding method.

510. **TECHNIQUE OF TEACHING VOCATIONAL AND TECHNICAL EDUCATION.**
(3-0) Cr. 3. F.W.S.
Prerequisite: Permission of instructor.
Teaching processes, methods of presentation and testing, lesson planning, and organization of instruction.

514. **FOUNDATIONS OF VOCATIONAL AND TECHNICAL EDUCATION.**
(3-0) Cr. 3. F.W.S.
Prerequisite: Permission of instructor. Sarchett.
Development and philosophy of vocational-technical education, federal and state legislation. State plans, divisions and types of programs.

516. **TRENDS IN VOCATIONAL-TECHNICAL EDUCATION.**
(3-0) Cr. 3. SS.
Prerequisite: Permission of instructor.
Brief review of the development of vocational and technical education. A study of the most recent trends in various types of schools offering vocational-technical education with respect to curriculum, qualifications and training of instructors, administration of program, requirements for program certification, and the developing ratio of technical, related, and general education within the curriculum.

518. **PROBLEMS IN INDUSTRIAL EDUCATION.**
(3-0) Cr. 3. SS.
Prerequisite: 415.
Initiating programs; program organization and development; purchasing materials, supplies, and equipment; facility planning and utilization; writing specifications; program evaluation; and other related problems.

519. **OCCUPATIONAL ANALYSIS AND COURSE CONSTRUCTION.**
(3-0) Cr. 3. F.W.S.
Prerequisite: Permission of instructor.
Course of study development based on occupational analysis. Compilation, arrangement, and limitations of instructional materials.

524. **CONFERENCE-LEADING TECHNIQUES.**
(6-0) Cr. 3. SS.
Prerequisite: Permission of instructor.
Study and practice of conference procedures and techniques as applied to teaching and advisory committee functions.

525. **COORDINATION OF PART-TIME COOPERATIVE INDUSTRIAL EDUCATION.**
(3-0) Cr. 3. SS.
Planning and cooperating with business and industry to provide part-time on-the-job training for high school student learners.

528. **PUBLIC RELATIONS FOR INDUSTRIAL AND TECHNICAL EDUCATION.**
(3-0) Cr. 3. SS.
Prerequisite: 514.
Identifying a plan of public relations for industrial and technical education; analysis of publics that need to be reached; effect of human relations on public relations; criteria for evaluation.

554. **DEVELOPMENT OF INDUSTRIAL EDUCATION.**
(3-0) Cr. 3. SS.
An evaluation of educational and industrial thought. Historical and philosophical development of industrial education to the present. Trends and implications.

555. **ADMINISTRATION AND SUPERVISION OF INDUSTRIAL EDUCATION.**
(3-0) Cr. 2 or 3. SS.
Prerequisite: Permission of instructor. Carver.
Administration, supervision, curriculum development, selection of staff, and public relations. Evaluating administrative and supervisory efforts; program modification. Field trips to schools and industries.

556. **CURRENT ISSUES AND MODERN CONCEPTS IN INDUSTRIAL EDUCATION.**
(3-0) Cr. 3.
Prerequisite: Fifteen credits in industrial education. Carver, Parks.
A critical analysis of industrial education in the evolving role of education. Newer concepts of teaching laboratory work; impact of research and experimentation; implications for curriculum change and program modernization.

557. **ORGANIZATION AND MANAGEMENT OF THE INDUSTRIAL EDUCATION LABORATORY.**
(3-0) Cr. 3. SS.
Prerequisite: Fifteen credits in industrial education. Carver, Parks.
Principles and practices involved in the planning, organization, and management of the school shop; responsibility of the school administrator and teacher; basic principles of planning; selection and purchase of machines, tools, equipment, and materials; maintenance, storage, and control of machines, tools, and equipment; managing the shop for effective work.

559. PROCESSES AND SYSTEMS IN AMERICAN INDUSTRY.
(3-0) Cr. 3. S.SS.
Prerequisite: Permission of instructor.
An exploratory study of modern manufacturing industries. Designed to prepare teachers to interpret industry through a better understanding of the facets; management, systems, controls, financing, and personnel.

570. ADMINISTRATION OF ACCIDENT PREVENTION PROGRAMS.
(3-0) Cr. 3. SS.
Prerequisite: 216, 316.
Effective methods of developing the background and motivation essential to accident prevention at various educational levels.

571. SEMINAR: PSYCHOLOGY OF SAFETY.
(2-0) Cr. 1. S.
Prerequisite: Nine credits in psychology and education, permission of instructor. Schwenk.
Review of literature in field of safety. Round-table discussions with state and national safety experts and public officials.

590. SPECIAL TOPICS IN INDUSTRIAL EDUCATION.
Cr. 1 to 5.
Prerequisite: Graduate classification in industrial education.
A. Industrial Arts.
B. Vocational-Technical.
C. Curriculum.
D. Evaluation.
E. Administration and Supervision.
F. Instructional Materials.
G. History and Philosophy.
J. Research.
K. Laboratory Problems.
L. Technical Training.
S. Safety Education.
T. Safety, Industrial Education.

593F. WORKSHOP IN INDUSTRIAL EDUCATION.
Cr. 1 to 5. SS.
Prerequisite: Fifteen credits in industrial education. Carver, Parks, Wolansky.

COURSES FOR GRADUATE STUDENTS, major or minor

615. SEMINAR.
Cr. 1 to 3. F.W.S.SS.
Prerequisite: Permission of instructor.

652. EVALUATION IN INDUSTRIAL EDUCATION.
(2 or 3-0) Cr. 2 or 3. SS.
Prerequisite: Fifteen credits in industrial education. Carver, Stephens.
Developing basic concepts. Techniques for evaluating student personnel, facilities, programs, staff, and other educational resources.

656. INSTRUCTIONAL MATERIALS FOR INDUSTRIAL EDUCATION.
(3-0) Cr. 3. SS.
Prerequisite: Fifteen credits in industrial education. Carver, Parks.
Examination of new equipment, materials, and techniques in using instructional materials in industrial education teaching.

657. CURRICULUM DEVELOPMENT IN INDUSTRIAL EDUCATION.
(3-0) Cr. 3. SS.
Prerequisite: Fifteen credits in industrial education. Carver.
Basic concepts, trends, practices, and factors influencing curriculum development; techniques, organization, and procedures; the course of study and its development in a given curriculum pattern.

699. RESEARCH.

INDUSTRIAL ENGINEERING

Joseph K. Walkup, B.M.E., I.E., Head of Department

The Graduate Faculty

Members: H.T. David, A.C. Kleinschmidt, G.M. Montag, G.W. Smith, J.K. Walkup

Associate Members: H.A. Cowles, J.C. Even, G.E. Lamp, K.L. McRoberts, C.E. Smith

The department offers work for the degree Master of Engineering and Master of Science with majors in industrial engineering and in engineering valuation, and for the degree Doctor of Philosophy with major in engineering valuation, and minor work to students taking work in other departments.

Prerequisite to major graduate work is the completion of a curriculum substantially equivalent to that required of undergraduate students in engineering at this institution.

Competence in a foreign language is required for the Master of Science and the Doctor of Philosophy degrees. (A score of 400 in the Educational Testing Service examination in French, German, Italian, Russian, or Spanish meets this requirement.) For the Master of Science degree the candidate's advisory committee may recommend the substitution of an alternative tool of research for the language requirement. Normally, this will be six credits of mathematics, statistics, or computer science courses available for graduate credit, minor only. There is no foreign language requirement for the degree Master of Engineering.

COURSES FOR GRADUATE STUDENTS, minor only

312, 313. INDUSTRIAL OPERATIONS RESEARCH.
(4-0) Cr. 4 each. 312: F.W; 313: W.S.
Prerequisite: 312: Math. 205; 313: 312. Stat. 341.
History and growth of operations research. The development of mathematical concepts and models concerned with engineering and management decisions. Single and multi-variate optimization models, e.g., linear programming, inventory theory, game theory, network analysis theory, and other deterministic and stochastic models.

361. QUANTITATIVE METHODS FOR INDUSTRIAL ENGINEERING.
(3-0) Cr. 3. F.W.S.
Prerequisite: 250 or 351; Stat. 342.
Adaptation and application of mathematical and statistical techniques to the analysis of problems of an engineering nature. Interpretation of the problems in physical terms.

404. ENGINEERING ECONOMY.
(2-2 or 3-0) Cr. 3. F.W.S.
Prerequisite: Econ. 242, I.Ad. 371.
Application of fundamentals of economics to engineering alternatives in planning, developing, and managing industrial projects.

407. ENGINEERING VALUATION.
(3-0) Cr. 3. F.W.S.
Prerequisite: Econ. 241, 3 credits of accounting.
Concepts of value, original cost, and reproduction cost, property records, methods of estimating depreciation for valuation and accounting; intangible values, cost values, earning values, rate base, and valuation for taxation, rates, financing, insurance, and sales.

416. PRODUCTION ANALYSIS.
(3-0) Cr. 3. S.
Prerequisite: 313.
Specialized mathematical techniques applied to industrial production management.

420. ENGINEERING SALES.
(3-0) Cr. 3. S.
Prerequisite: 304, 480.
Concepts involved with selling technical goods and services. Application of legal, economic, and ethical principles involved in the preparation of specifications, bids, and contracts.

421. SAFETY ENGINEERING.
(3-0 or 3-3) Cr. 3 or 4. F.S.
Prerequisite: 250 or 351.
Principles of accident prevention in industry; training for and selling safety. Safe machine design and guarding. Industrial compensation and safety legislation.

423. JOB COMPENSATION.
(2-3) Cr. 3. F.
Prerequisite: 475.
Study of the principal pressures and their influence on forms and levels of job compensation.

424, 425. MANPOWER MANAGEMENT.
Cr. 3 each. 424: (3-0) F.W; 425: (2-2) W.S.
Prerequisite: 424: 250 or 351; Psych. 101. 425: 424.
Employer-employee problems and desirable approaches to their solution based upon the application of the principles and techniques of selection and placement of industrial manpower, personnel management and control, and wage and salary administration.

426. PERSONNEL MANAGEMENT.
(3-0) Cr. 3. S.
Prerequisite: 425.
Advanced study of modern personnel management techniques which influence the design of company organization, policies, and the resulting practices and procedures. Employee instruction, training, education, and evaluation emphasized.

441. INDUSTRIAL ENGINEERING DESIGN I.
(3-4) Cr. 5. F.W.
Prerequisite: 273, 312, 404.
Operations, machines, and processes required for typical manufacturing problems; selection, specification, and layout of equipment and plant facilities, balancing schedules, budget preparation.

442. INDUSTRIAL ENGINEERING DESIGN II.
(3-4) Cr. 5. W.S.
Prerequisite: 313, 441.
The development of organization charts and standard crews; the determination and the design of records of performance to be used in the administrative control of a typical manufacturing enterprise.

443. INDUSTRIAL ENGINEERING DESIGN III.
(2-2) Cr. 3. S.
Prerequisite: Credit or classification in 442.
The development and application of inventory records, load charts, production orders, schedules, production reports, progress reports and control reports to a manufacturing problem in such a manner as to keep a continuous comparison between planned and actual results.

448. INDUSTRIAL DYNAMICS.
(1-4) Cr. 3.
Prerequisite: 351, 404.
Information-feedback characteristics of industrial systems; interaction of organization structure, policies, and time delays in the success of an enterprise; relationships between flow of information, money, materials, orders, personnel, and capital equipment in an organization or industry. Model building and computer simulation are utilized.

462. ENGINEERING INSPECTION.
(3-0) Cr. 3. S.
Prerequisite: 250 or 351; Stat. 105.
Inspection of department functions and organization, quality-control procedures, acceptance sampling, and cost studies.

475. MOTION AND TIME STUDY.
(2-3) Cr. 3. W.S.
Prerequisite: 351.
Principles and methods of motion and time study as employed in industrial operations.

492. SEMINAR.
(1-0) Cr. R; W.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

504. ADVANCED ENGINEERING ECONOMY.
Cr. 3 to 5. F.W.S.
Prerequisite: 404.
Advanced engineering economic analysis; engineering, financial and intangible factors influencing management decision for expenditure of funds. Applications of capital recovery and physical plant replacement theories.

505. CAPITAL EXPENDITURE PROGRAMMING.
(3-0) Cr. 3. F.
Prerequisite: 504.
Determination of capital expenditure policy and budget. Factors influencing the priority queue (urgency) and the optimum-rationed level of expenditures. Project request, consideration, revision, screening, rejection, postponement, approval, subsequent verification, and feedback processes. Planning and control of the capital expenditure budget and sources of funds.

506. ENGINEERING ASPECTS OF PUBLIC UTILITY ADMINISTRATION.
Cr. 2 to 5 each time elected. F.
Prerequisite: 404, 407.
Engineering problems arising from the regulation of service and rates, the taxation, and the operation of public utilities.

507. DEPRECIATION ESTIMATES.
(3-0) Cr. 3. W.S.
Prerequisite: 407.
Collection and analysis of retirement data. Techniques required for the construction of survivor, probable life, condition percent, and accrued depreciation curves for property groups. Analysis of the effect of growing, declining, and stable properties on depreciation estimates.

509. ENGINEERING VALUATION PRACTICE.
(2-3) Cr. 3. F.S.
Prerequisite: 407.
Application of principles of engineering valuation, including field work, preparation and pricing of inventories, valuations for utility rates, security regulations, condemnations, sales, estate settlements, and determining fixed capital costs.

511. OPERATIONS-RESEARCH CONCEPTS.
(4-0) Cr. 4. F.
Prerequisite: 304, Math. 213, Stat. 341.
Theory and development of operations-research concepts and techniques within industrial contexts. Includes linear programming, dynamic programming, queueing theory, and simulation.

512. QUEUEING THEORY AND APPLICATIONS.
(3-0) Cr. 3. S.
Prerequisite: 511.
Development and use of mathematical models for the analysis of queueing systems as applied primarily to industrial situations. Steady state as well as transient systems are considered.

515. MANAGEMENT SCIENCE I.
(3-0) Cr. 3. W.
Prerequisite: 313.
Development of scientific models and analogies applicable to engineering management; investigation of existing mathematical methods; operations research.

516 MANAGEMENT SCIENCE II.
(3-0) Cr. 3. S.
Prerequisite: 515.
Case studies and industrial problems. New methods and theories in management science and operations research.

522. ENGINEERING ASPECTS OF WAGE DETERMINATION.
(2-3 or 6) Cr. 3 or 4. S.
Prerequisite: 423.
Critical survey of wage programs founded on job evaluation; merit rating, wage incentives, basic hourly wage curve, salary classifications, and administrative programs.

531. INDUSTRIAL STATISTICS: PROCESS CONTROL.
(Stat. 531) See Statistics.

533. INDUSTRIAL STATISTICS: RELIABILITY.
(Stat. 533) See Statistics.

539. OPERATIONS RESEARCH.
(Stat 539) See Statistics.

540. OPERATIONS RESEARCH METHODS AND ECONOMIC ANALYSIS.
(Stat. 540) See Statistics.

545. ADVANCED INDUSTRIAL ENGINEERING DESIGN.
Cr. 3 to 5 each time elected. F.W.S.
Prerequisite: 441.
Planning and controlling the manufacturing plant. Theory of facilities selection and layout; balancing operations and schedules; design of the manufacturing plant; structure of the organization and system. Control techniques, budgets, and realization comparison.

551. INDUSTRIAL ENGINEERING CONCEPTS.
Cr. 3 to 5. F.
Prerequisite: 250 or 351; 480, Econ. 242.
Development in depth of theoretical and practical concepts of current industrial engineering practice.

552. INDUSTRIAL ORGANIZATION THEORY.
(3-0) Cr. 3. S.
Prerequisite: 551.
Examination of theories of organization with the purpose of explaining, predicting, and influencing organization behavior. Requirements for design and control of industrial organizations and their components.

571. THEORY AND PRINCIPLES OF WORK-TIME RELATIONSHIPS.
(2-3 or 3-6) Cr. 3 or 5. S.
Prerequisite: 441.
Evaluation of time-study systems using predetermined elemental time standards; comparison with stop-watch time study. Applications to industrial situation. Analysis of current literature.

581. LEGAL ASPECTS OF ENGINEERING ADMINISTRATION.
(3-0) Cr. 3. F.
Prerequisite: 250 or 351, and 480 or I.Ad. 365A.
Engineering management contacts with public administrators and administrative law.

582. TAXATION ASPECTS OF ENGINEERING ADMINISTRATION.
(3-0) Cr. 3. W.
Prerequisite: 581, I.Ad. 371.
Concepts of advalorem, income, and excise taxes and their effects on industrial operations and policy making.

583. PATENT ASPECTS OF ENGINEERING ADMINISTRATION.
(3-0) Cr. 3. S.
Prerequisite: 480 or I.Ad. 365A desirable.
Management problems concerning patents, trademarks, franchises, copyrights, and royalties.

590. SPECIAL TOPICS.
Cr. 1 to 5 each time elected.
A. Management problems in engineering valuation and depreciation.
B. Management problems in personnel.
C. Management problems in industrial engineering.
D. Management problems in regulated industries.

COURSES FOR GRADUATE STUDENTS, major or minor

608. **DEPRECIATION ACCOUNTANCY.**
Cr. 2 to 6 each time elected. F.S.
Prerequisite: 507.
Unit and group methods of accounting for depreciation; reserve requirements; adjustment of depreciation rates and reserves; classification of accounts, property accounting methods. Income tax regulations.

624. **FACTORY PERSONNEL.**
Cr. 3 to 5. F.W.S.
Prerequisite: 425, 551.
Employment departments: time and wage problems; shop committees; housing conditions, and industrial relations.

681. **COURT AND COMMISSION PRACTICE.**
Cr. 2 to 6 each time elected. W.S.
Prerequisite: 681A: 581, 608; 681B: 581.
A. Utility rates, property valuation, and depreciation.
B. Legal relations in industry.

690. **SEMINAR.**
Cr. R; F.W.S.

699. **RESEARCH.**
Cr. 1 to 5.
A. Industrial Engineering Research.
B. Engineering Valuation Research.

INDUSTRIAL RELATIONS

Harold W. Davey, Ph.D., Chairman, Advisory Committee

Advisory Committee: Donald E. Boles, Ph.D.; Terry L. Dickinson, Ph.D.; Robert O. Richards, Jr., Ph.D.; Clifford E. Smith, Ph.D.

Work is offered for the degree Master of Science with major in industrial relations. This is a multidisciplinary degree offered under a cooperative arrangement by the departments of Economics, Industrial Engineering, Political Science, Psychology, and Sociology.

Graduate students in industrial relations usually receive their undergraduate background in economics, industrial (business) administration, industrial engineering, political science, psychology, or sociology. Admission is not restricted to students from these majors, however. Students entering industrial relations ideally should have a broad background in the social sciences. One such undergraduate program at Iowa State University is the industrial relations program in the distributed studies major of the College of Sciences and Humanities.

The program in industrial relations is regarded as education for both professional practice and scientific inquiry. Through the Industrial Relations Center and its interdisciplinary faculty, facilities and opportunity exist for research of both a fundamental and applied nature on a variety of problems concerned with the world of people at work.

A student majoring in industrial relations will choose a major professor from the graduate faculty of the cooperating departments, who ordinarily will be a member of the industrial relations advisory committee. The student's program of study will be developed with the guidance of an advisory committee nominated by his major professor, approved by the industrial relations advisory committee and appointed by the dean of the Graduate College. The program of study will include course work from three of the disciplines represented in the industrial relations program.

Each student will select two of the five cooperating disciplines (economics, industrial engineering, political science, psychology, and sociology) as a major field. Approximately two-thirds of the student's program (including thesis) will comprise the major field. The remainder of the program will include Statistics 401 and other elective courses. Statistics 402 is strongly recommended.

Normally, candidates for the degree Master of Science are required to complete satisfactorily 45 credits of acceptable graduate work including preparation of a thesis. With the approval of the student's advisory committee, however, candidates may fulfill requirements by completing satisfactorily 54 credits of course work, in which case preparation of a thesis and Statistics 401 are not required. Under this degree program a student will select courses from four of the five cooperating departments. Satisfactory completion of a comprehensive examination is required.

A foreign language is not required.

The verbal and quantitative aptitude tests of the Graduate Record Examination are required of all applicants to the industrial relations program.

Courses appropriate for the Master of Science degree are determined by the student's advisory committee. Recommended courses for graduate students majoring or minoring

in industrial relations include: Econ. 441, 445, 590, 591, 592, 593, 594, 595; Psych. 440, 441, 450, 451, 522, 523, 550, 551, 580, 581; Soc. 401, 410, 480, 570, 600, 601, 698A, 698D; I.E. 424, 425, 426, 448, 475, 480, 522, 571, 581, 590, 624; Pol.S. 420, 421, 422, 520. See departmental listings for course descriptions and credits.

INSTITUTION MANAGEMENT

Marjorie M. McKinley, Ph.D., Head of Department

The Graduate Faculty

Members: G.M. Augustine, M.M. McKinley, G.M. Montag

The department offers work for the degree Master of Science with major in institution management and minor work to students taking major work in other departments.

Work may be taken for the degree Doctor of Philosophy as a joint major with departments offering work for this degree in home economics, engineering, economics, or other related areas.

The usual prerequisite to major graduate work is the completion of 10 quarter credits in institution management and six in food and nutrition, and fundamental preparation in accounting, chemistry, and bacteriology. The exact requirements will depend upon the field of work the student expects to pursue.

There is no foreign language requirement for the degree Master of Science. A foreign language is not required for the degree Doctor of Philosophy unless skill in a particular foreign language is needed in an individual program of study.

COURSES FOR GRADUATE STUDENTS, minor only

450. HOTEL AND RESTAURANT ACCOUNTING.
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: 487, I.Ad. 384.
Accounting procedures applicable to hotels and restaurants. Uniform systems of accounts for hotels and restaurants.

460. LEGAL ASPECTS OF HOTEL AND RESTAURANT MANAGEMENT.
(3-0) Cr. 3. Alt. S, offered 1973.
Prerequisite: 487, I.Ad. 365D.
Laws relating to the ownership and operation of hotels, restaurants, and similar institutions. The responsibility of management and employees to guests and the public.

470. QUANTITY FOOD PRODUCTION AND SERVICE METHODS.
Cr. arr. SSI. or SSII.
Prerequisite: A college course in principles of food preparation.
Methods of producing food in quantity using institution equipment. Interpretation for teaching nonsupervisory food service workers. Designed to contribute to preparation of teachers of vocational food service courses. Not accepted in lieu of I.Mgt. 380 for Iowa State institution management and food and nutrition majors.

484. PURCHASING AND INVENTORY MANAGEMENT.
(3-3) Cr. 4. F.W.
Prerequisite: 380 or F.&N. 303.
Principles of buying food and inventory management for various types of quantity food service. Emphasis on specifications and various factors affecting quality. Field trips required.

485. LAYOUT AND EQUIPMENT.
(3-3) Cr. 4. S.SS.
Prerequisite: Credit or classification in 380.
Food facilities planning and design; selection of equipment with emphasis on materials, construction, and specifications. Field trips required.

487. ORGANIZATION AND MANAGEMENT.
(3-0) Cr. 3. W.SS.
Prerequisite: 380.
Functions of management; procedures and controls applicable to food service and housing organizations; emphasis on financial management including control of food, labor, and other variable costs.

488. PERSONNEL MANAGEMENT IN INSTITUTIONS.
(3-0) Cr. 3. F.S.
Prerequisite: 487.
Principles of management and personnel organization as applied to food and housing organizations. Principles and practices related to personnel recruitment, selection, training, employee-employer relations, and wage administration. Union and government considerations.

489. HOUSE ADMINISTRATION.
(2-3) Cr. 3. W.
Prerequisite: 485.
Management considerations of residence and housekeeping functions in institutions. Selection and maintenance of institutional furnishings and materials, equipment, and supplies. Field trips required.

490. SPECIAL PROBLEMS.
Cr. arr.
Prerequisite: Permission of department head.
A. Quantity Food Production.
B. Organization and Management.
C. General.
D. Housing.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

500. **SHORT COURSE.**
Cr. arr.

580. **QUANTITY FOOD DEVELOPMENT.**
(1-6) Cr. 3. S.
Prerequisite: 380, F.&N. 411, permission of department head.
Experimental approach to methods in quantity food production as related to time factor, institution equipment, and proportions of ingredients.

585. **CATERING.**
(2-6) Cr. 4. F.W. Alt. SSI.
Prerequisite: 380.
Management, preparation, and presentation of special food service functions. Appreciation of historical and cultural background of U.S. regional and foreign foods. Creative experiences with gourmet-type foods. Advance reservation with department head required.

590. **SPECIAL TOPICS AND WORKSHOPS.**
Cr. arr.
Prerequisite: Permission of department head.
A. Food Service Management.
B. Housing Service Management.
C. General.

COURSES FOR GRADUATE STUDENTS, major or minor

601, 602. **DECISION OPTIMIZATION IN INSTITUTION MANAGEMENT I, II.**
(3-0) Cr. 3 each. 601: W; 602: S.
Prerequisite: Nine quarter credits in institution management including I.Mgt. 487, permission of department head. Montag.
Use of quantitative methods of operations research and engineering economy to optimize decisions in institution food and housing service systems.

604. **SEMINAR.**
Cr. arr. F.W S. McKinley, Montag.

608. **ADMINISTRATION PROBLEMS.**
(1-6) Cr. arr. F.W.S.
Prerequisite: 487. McKinley.
Consideration of advanced administrative problems. Case studies in food service and housing departments of Iowa State University, Memorial Union, and other institutions.

699. **RESEARCH.**

JOURNALISM AND MASS COMMUNICATION

James W. Schwartz, M.S., Head of Department

The Graduate Faculty

Members: C. Hamilton, J.W. Schwartz, J.D. Shelley

Associate Members: R.L. Crom, R.T. Fox, J.K. Hvistendahl, K.R. Kern, J.P. Yarbrough

The department offers work for the degree of Master of Science with a major in journalism and mass communication, and minor work to students taking major work in other departments.

For major work, a student must have a bachelor's degree in journalism or in a subject matter area which he wishes to combine professionally with advanced training in journalism and mass communication.

There is no foreign language requirement for the degree Master of Science.

COURSES FOR GRADUATE STUDENTS, minor only

415. **PUBLIC OPINION AND MASS COMMUNICATION.**
(3-0) Cr. 3. S.
Survey and synthesis of major factors influencing public opinion and their relevance to both detecting and developing mass communication strategies.

417. **PICTORIAL COMMUNICATION.**
(3-0) Cr. 3. F.S.
A survey of the uses in communication of photographs, drawings, graphs, charts, maps, and nonword symbols. Special emphasis on how to communicate by means of pictures.

425. **IMPACT OF COMMUNICATION TECHNOLOGY ON PEOPLE AND SOCIETIES.**
(3-0) Cr. 3. S.
Seminar to study present and potential effects on people, institutions, and societies of increasingly sophisticated modes of mass communication; television, computerized publications, rocket transportation, facsimile, radar, microwave, lasers, masers, satellites, etc. Focus on how these may affect men's abilities to solve their daily problems, determine their and their countries' destinies, and understand themselves and their fellow men.

430. LAW OF COMMUNICATIONS.
(3-0) Cr. 3. F.W.S.
Libel, slander, lottery, copyright; postal laws; the Federal Communications Act; laws affecting advertising and legal publication.

431. HISTORY OF JOURNALISM.
(3-0) Cr. 3. W.S.
Development of American journalism from colonial times. Emphasis on growth of freedom of the press concept, ethical standards, and role of the press in growth of American culture.

440. INTERNATIONAL COMMUNICATION AND THE FOREIGN PRESS.
(3-0) Cr. 3. F.
Study of world news communication systems encompassing news-gathering agencies, the role of foreign correspondents, and the factors determining the flow of world news. Comparative analysis of mass media systems in developed countries.

462. PRESS FREEDOM, RESPONSIBILITY, AND ETHICS.
(3-0) Cr. 3. F.W.SSII.
Philosophies on which the concept of freedom of communication in America is based; theory of responsibility assumed by mass communication media as related to freedom and other privileges; ethical problems faced by users of printed and electronic media.

463. RESEARCH METHODS AND JOURNALISM.
(3-0) Cr. 3. F.
Investigation of the scientific process in the context of reporting and interpreting research results for professional and lay publics.

464. JOURNALISM AND LITERATURE.
(3-0) Cr. 3. F.W.
A study of renowned magazine and newspaper writers and analysis of their writing styles, use of language and the other factors that led to achievement of permanent places in the history of American journalism and, often, to literary eminence as well.

480. THE TEACHING OF HIGH SCHOOL JOURNALISM.
(3-0) Cr. 3. W.SSII.
Seminar on the techniques of teaching high school journalism coordinate with advising high school publications. For the journalism major preparing for high school teaching and for the nonmajor who could expect a journalism course assignment as part of his high school teaching program.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

510. PROCESS AND STRATEGY OF MASS COMMUNICATION RESEARCH.
(4-0) Cr. 4. F.
Prerequisite: Graduate standing or permission of instructor.
Nature of science and the research process. Relationship of theory, hypotheses, and measurement models. Communication research techniques and study analysis.

512. THEORIES OF MASS COMMUNICATION.
(3-0) Cr. 3. W.
Prerequisite: 510 or permission of instructor.
Examination of major areas of research activity and theoretic development related to the organization, functions, and effects of mass communication.

515. STRATEGIES OF COMMUNICATION AND PERSUASION.
(3-0) Cr. 3. S.SSI.
Prerequisite: 512 or permission of instructor.
The process of developing professional communication and persuasion strategies, with emphasis on problem definition, behavioral specification of objectives, situation analysis, strategy formulation and justification through application of communication theories and research results.

526, 527, 528. REPORTING ON SCIENCE AND TECHNOLOGY.
(1-4) Cr. 3 each. Yr.
Prerequisite: 526: Graduate standing or permission of instructor; 527: 526 or equivalent; 528: 527 or permission of instructor.
Writing and editing problems of the communicator who mediates between scholar, scientist, and various reading publics. Communication objectives, audience analysis, code selection, treatments, media characteristics.

530. THE PRESS AND SOCIETY: INTERRELATIONSHIPS.
(3-0) Cr. 3. F.
Prerequisite: Graduate standing or permission of instructor.
The press and its functions in a democratic society; conflicts between the press and social institutions; legal, social, and political controls of the press; solutions to conflicts.

545. MASS COMMUNICATION IN DEVELOPING NATIONS.
(3-0) Cr. 3. W.
Prerequisite: 440 or equivalent.
Evaluation and comparison of traditional and transitional systems of communication; study of the role of communications in societal growth; development, structure, and functions of systems in Africa, Asia, and Latin America.

590. SPECIAL PROBLEMS.
Cr. arr.
Prerequisite: Permission of instructor.
A. Broadcasting.
B. Visual Pictorial.
C. Advertising Public Relations.
D. Media Management.
E. Law.
F. History.
G. International.
I. Audiences and Effects.
K. Technology.

COURSES FOR GRADUATE STUDENTS, major or minor

650. SEMINARS IN JOURNALISM COMMUNICATION.
Cr. 3 each. Offered as demand warrants from following topic list.
A. Visual Pictorial Communication.
B. Communication History.
C. Society and Mass Communication.
D. International Communication.
E. Communication Law.
F. Audiences and Effects.

699. RESEARCH.

LANDSCAPE ARCHITECTURE

Thomas A. Barton, M.L.A., Head of Department

The Graduate Faculty

Member: T.A. Barton

Associate Members: R.W. Dyas, K.F. Lane

The department offers work for the degree Master of Landscape Architecture with major in landscape architecture. Minor work is offered to students taking major work in other departments.

The degree Master of Landscape Architecture is granted upon the completion of two years of graduate study with a minimum of 60 credits in residence at Iowa State University.

Satisfactory completion of L.A. 500, 514, 515, 516, or their equivalents, and the acceptance of a thesis or a terminal project are required for the M.L.A. degree.

Students desiring to major in landscape architecture should present credits substantially equivalent to those secured by undergraduate students in the curriculum in landscape architecture at this institution.

There is no uniform foreign language requirement for the degree Master of Landscape Architecture; however, a satisfactory reading knowledge of German, French, Russian, or Spanish will be required when specifically recommended by the student's advisory committee.

COURSES FOR GRADUATE STUDENTS, minor only

404. OUTDOOR RECREATION IN THE UNITED STATES.
(3-0) Cr. 3. W.
Survey of historical aspects, current problems, and future trends; influence of natural resources. Introduction to planning and selection of sites for recreation use.

411. LAND ANALYSIS.
(2-9) Cr. 5. F.S.
Analysis of the physical and biological processes of land. Investigations are made of limiting factors and opportunities as these are employed in planning and design for human use. Instruction includes visiting professors from allied fields.

412. LANDSCAPE EVALUATION.
(1-12) Cr. 5. S.
Prerequisite: 411.
Interpretation and communication of landscape qualities; sketching, photography; graphic and oral presentations; field trips.

413. ADVANCED LANDSCAPE DESIGN.
(1-12) Cr. 5. S.
Prerequisite: 334, 352.
Depth study of a comprehensive landscape architectural problem situated within an existing environment. Research, preliminary studies, conferences, and presentation of recommendations.

436. ADVANCED PLANTING DESIGN.
(2-9) Cr. 5. W.
Prerequisite: 334.
Advanced study of planting design.

445. PLANNING RECREATION SYSTEMS.
(3-0) Cr. 3. S.
Prerequisite: 404.
Survey of techniques for planning recreation systems at city, county, state, regional, and national levels; criteria for determining location of recreation sites and their distribution.

490. SPECIAL PROBLEMS.
Cr. 2 to 4.
Prerequisite: Permission of instructor.
Investigation of an approved topic of special interest to the student. Election of course and topic must be approved in advance. Offered only on a satisfactory-fail basis.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

500. SEMINAR.
(1-0) Cr. 1. F.W.S.

514, 515, 516. LANDSCAPE ARCHITECTURE —DESIGN.
(0-9) Cr. 3 each. F.W.S.
Prerequisite: 411.
Programming, analysis, synthesis, and presentation phases in urban design, regional design, and recreational design and planning. An exploratory study of innovations in policy and design methods preliminary to preparation of a thesis or a terminal project.

517. TERMINAL PROJECT.
Cr. arr. F.W.S.
Comprehensive study and original development of a project selected by the student and approved by the department. The completed project must be submitted to and approved by a graduate college faculty committee as evidence of mastery of the principles of landscape architecture.

590. SPECIAL TOPICS.
Cr. 2 to 5 each time elected.
Prerequisite: Permission of instructor.
A. Landscape Design.
B. Planting Design.
C. Details of Construction.

COURSE FOR GRADUATE STUDENTS, major or minor

699. RESEARCH.

URBAN PLANNING

Thomas A. Barton, M.L.A., Professor in Charge

The Graduate Faculty

Member: T.A. Barton

Associate Members: W.A. Malone, F.W. Osgood, R.F. Sale

Graduate study for the degree Master of Science with a major in town and regional planning is administered by the Department of Landscape Architecture. Minor work is offered to students taking major work in other departments.

The degree Master of Science, major in town and regional planning, is granted upon the completion of two years of graduate study with a minimum of 60 credits in residence at Iowa State University and a total of 77 credits. Planning specializations available include:

Administration	Urban Design
Economic Planning	Human Resources Planning
Resource Conservation	Housing
Urban Renewal	Systems Analysis
Transportation Planning	State and Regional Planning

A student expecting to do major work in town and regional planning should previously have taken courses in the principles of economics, political science, sociology, statistics, computer science, urban planning, design, and graphic presentation. If a student has not previously taken a computer science undergraduate course, he will be required to study this subject as supporting work, without graduate credit, early in his graduate program. In the case of deficiencies in other areas, supporting work in those areas may also be required.

For the degree Master of Science, the foreign language requirement, if any, is established on an individual basis by the student's advisory committee.

Satisfactory completion of the core requirements and the acceptance of a thesis (12 credits) is required for the M.S. degree. The core requirements are:

Planning Theory	6 credits (Ur.Pl. 561, 562)
Planning Techniques	3 credits (Ur.Pl. 571)
Background Components	9 credits (Econ. 461, Pol.S. 512, Soc. 410)
Planning Law	3 credits (Ur.Pl. 592)
Planning Studio	9 credits (Ur.Pl. 531, 532, 533)
Planning Research	3 credits (Ur.Pl. 541)
Seminars	4 credits (Ur.Pl. 511, 512, 513, 614)

In addition, the student is expected to complete 3 months of acceptable work experience in a planning office between his first and second year.

For students interested in interdisciplinary study of housing, a program is administered in cooperation with the departments of Applied Art, Architecture, Family Environment, and Landscape Architecture. For details consult the head of the department.

COURSES FOR GRADUATE STUDENTS, minor only

372. PLANNING ANALYSIS AND TECHNIQUES.
(4-0) Cr. 4. W.
Prerequisite: 253.
An introduction to existing and emerging techniques for the preparation and criticism of plans and planning studies. Topics covered include economic, population, activity, and physical studies, and studies for the location, quantity, intensity and timing of land uses and public services. Exercises in the use of sources and techniques.

380. STATE AND REGIONAL PLANNING.
(3-0) Cr. 3. F.
Prerequisite: 253 or 270.
State and regional planning, development, theories and functions, analysis techniques, and methods for guiding development and policy implementation.

383. THEORY OF THE PLANNING PROCESS.
(4-0) Cr. 4. W.
Prerequisite: 253.
The nature of physical planning and its relation to social and economic planning; levels of planning; place of planning in decision making and major decision-making groups; steps in the planning process; uses and limitation of knowledge in planning; relation of facts and values.

395. HOUSING AND URBAN RENEWAL.
(3-0) Cr. 3. S.
Prerequisite: 253 or 270.
Guidelines for housing policy formulation as a part of the over-all planning process in urban areas. Includes analysis of housing needs, regulation, stimulation, renewal, and replacement of housing through public policy. The urban renewal process; analysis of various urban renewal programs; residential conservation, rehabilitation, and redevelopment; and commercial and industrial renewal.

431. REGIONAL PLANNING.
(0-9) Cr. 3. F.
Prerequisite: Permission of instructor.
Preparation of a comprehensive plan for a metropolitan or resource region.

432. URBAN DEVELOPMENT PLANNING.
(0-9) Cr. 3. W.
Prerequisite: 431, permission of instructor.
Preparation of a comprehensive plan, including alternatives. Preparation of selected effectuating devices for one or more of these alternative plans.

433. URBAN DEVELOPMENT PROGRAMMING.
(0-9) Cr. 3. S.
Prerequisite: 432, permission of instructor.
The programming of plans through time, by such means as community renewal programming and urban renewal projects, and planning-programming-budgeting procedures.

490. SPECIAL PROBLEMS.
Cr. 2 to 4.
Prerequisite: Permission of instructor.
Investigation of an approved topic commensurate with student's interest and ability. Offered only on a satisfactory-fail basis.

492. PLANNING LAW, ADMINISTRATION AND IMPLEMENTATION.
(5-0) Cr. 5. F.
Prerequisite: 253.
The basis in constitutional, common, and statute law for the powers and duties of planning authorities and the powers of plan effectuation. Problems of balancing public and private interest as revealed in study of leading court cases. The administration of planning agencies and programs.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

511. HISTORY AND DEVELOPMENT OF PLANNING.
(2-0) Cr. 2. F.
Evolution of planning in the United States and other selected countries to relate current status and future potentials. Relates urbanization process to history and development of planning to meet local, metropolitan, regional, state, and national needs.

512. URBAN PLANNING PROFESSION.
(1-0) Cr. 1. W.
Prerequisite: 511.
Various elements of public planning and the planning office, including comprehensive plan, zoning, planning commission, urban renewal, housing authority, planning administration, and other important aspects of the planning profession.

513. SEMINAR.
(1-0) Cr. 1. S.
Prerequisite: 512.

531, 532, 533. URBAN AND REGIONAL PLANNING STUDIO.
(0-9) Cr. 3 each. 531: S; 532: F; 533: W.
Practice in the advanced level application of existing knowledge to planning projects, with emphasis on new towns, urban regions, comprehensive planning, and urban development programming.

541. URBAN PLANNING RESEARCH METHODS.
(2-3) Cr. 3. S.
Research methods for the discovery of new knowledge in urban and regional planning. Research of various types and sources of data and information systems.

561, 562. THEORY OF URBAN PLANNING.
(3-0) Cr. 3 each. 561: W; 562: S.
Prerequisite: Econ. 462 or graduate classification in town and regional planning.
561: Advanced theory of physical planning as a science. Land development models for planning purposes. Attention to the theories from which the models derive and the information systems which they require. 562: Advanced theory of physical planning as an art. Value conflicts in physical planning and arrangements, such as operational gaming, for accommodating these conflicts.

571. TECHNIQUES OF URBAN PLANNING.
(3-0) Cr. 3. W.
Prerequisite: 372 or graduate classification in town and regional planning.
Advanced qualitative and quantitative techniques in the preparation and programming of physical plans. Emphasis on new techniques derived from advanced planning theory.

590. SPECIAL TOPICS.
Cr. 1 to 3 each time elected.
Prerequisite: Permission of instructor.
D. Urban Development Planning and Programming.
E. Urban Renewal.
F. Regional and State Planning and Programming.
G. Simulations in Urban Planning.
H. Housing.
I. New Towns Planning.
J. Urban Planning in Underindustrialized Areas.

592. PLANNING LAW, ADMINISTRATION AND EFFECTUATION.
(3-0) Cr. 3. F.
Process of administration and implementation of planning programs through planning law. Effective management of the urban environment. Powers and duties of planning authorities and the powers of plan effectuation. Problems of balancing public and private interest as revealed in study of leading court cases.

COURSES FOR GRADUATE STUDENTS, major or minor

614. SEMINAR.
(1-0) R; S.
Prerequisite: 513.

699. RESEARCH.

MATHEMATICS

Wilfred E. Barnes, Ph.D., Head of Department

The Graduate Faculty

Members: A. Alexander, B.C. Arnold, W.E. Barnes, B.C. Carlson, P. Colwell, J.L. Cornette, S.E. Dickson, J.A. Dyer, A.M. Fink, R.J. Gregorac, J.J.L. Hinrichsen, R.F. Keller, R.J. Lambert, C.G. Maple, J.C. Mathews, D.E. Sanderson, G. Seifert, A.K. Steiner, E.F. Steiner, B. Vinograde, H.J. Weiss, F.M. Wright
Associate Members: D.E. Arganbright, R.S. Dahiya, W.J. Gorman, K.A. Heimes, I.E. Hentzel, R.H. Homer, D.L. Isaacson, W.J. Jameson, J.C. Kegley, O.C. Kreider, C.H. Lindahl, R.K. Meany, E.J. Peake, G.W. Peglar, S. Silverston, R.H. Sprague, G.O. Strawn, R.J. Tondra

The department offers work for the degrees Master of Science and Doctor of Philosophy with majors in mathematics and in applied mathematics, and minor work to students taking major work in other departments.

Students desiring to do graduate work with a major in this department should present at least 18 quarter credits of work in mathematics beyond calculus. It is desirable that this should include advanced calculus and abstract algebra.

The M.S. degree in this department may be taken either with or without thesis. Candidates for the M.S. and Ph.D. degrees must pass a written comprehensive examination covering basic graduate work. There is no foreign language requirement for the M.S. degree; for the Ph.D. ability to use two foreign languages (normally chosen from French, German, and Russian) as effective research tools in the student's area of specialization is required.

Master of Science candidates must have one year and Doctor of Philosophy candidates must have two years of supervised teaching experience. These minima are subject to increase in individual cases upon recommendation of the student's advisory committee and approval of the department head.

COURSES FOR GRADUATE STUDENTS, minor only

301, 302, 303. INTRODUCTION TO ABSTRACT ALGEBRA.
(3-0) Cr. 3 each. 301: F.W.SS; 302: W.S.SS; 303: F.S.
Prerequisite: 202.
Certain algebraic structures and their transformations, including groups, rings, and vector spaces.

307. THEORY OF MATRICES.
(3-0) Cr. 3. F.S.SS.
Prerequisite: 112.
Matrices and quadratic forms in the real and complex number fields.

308. APPLICATIONS OF LINEAR ALGEBRA.
(3-0) Cr. 3. S.
Prerequisite: 205 or 303 or 307.
Linear programming; applications of canonical matrices.

321, 322. INTRODUCTION TO APPLIED MATHEMATICS I, II.
(3-0) Cr. 3 each. F.W.S.SS.
Prerequisite: 213.
321: Systems of linear differential equations, mechanical-electrical circuits. Laplace transform. 322: Fourier series, partial differential equations, Bessel and Legendre functions.

330. TOPICS IN EUCLIDEAN GEOMETRY.
(3-0) Cr. 3. S.SS.
Prerequisite: 202.
Concepts and properties of Euclidean geometric systems.

331, 332, 333. TOPOLOGY.
(3-0) Cr. 3 each. Yr.
Prerequisite: 202.
Topological properties of finite dimensional Euclidean space. Metric spaces and continuous transformations. Abstract spaces, continua, convergence, and fixed point theory.

406. INTRODUCTION TO NUMERICAL TECHNIQUES FOR COMPUTERS.
(Com.S. 406) (3-2) Cr. 3. F.W.S.
Prerequisite: 112, Com.S. 201.
Finding roots of equations and solving systems of linear equations. Iterative methods; programming these methods for computer solution.

407, 408. NUMERICAL ANALYSIS I, II.
(Com.S. 407, 408) (3-0) Cr. 3 each. 407: W; 408: S.
Prerequisite: 213, Com.S. 201.
Interpolation, differences, numerical integration and numerical solution of ordinary differential equations. Computer solutions emphasized.

409, 410, 411. MULTIVARIABLE CALCULUS AND COMPLEX VARIABLES.
(3-0) Cr. 3 each. 409: F.W.SS; 410: W.S.SS; 411: F.S.
Prerequisite: 409: 213; 410: 409; 411: 410 or 415.
Certain frequently applied mathematical concepts presented with enough theory to promote understanding of applications. 409, 410: Calculus of functions of several variables, including vector calculus, line, surface and multiple integrals. 411: Functions of a complex variable, including differentiation, integration and series expansions, residues and applications to evaluation of integrals, conformal mapping.

414, 415, 416. ADVANCED CALCULUS.
(3-0) Cr. 3 each. Yr.
Prerequisite: 202.
414: Normed linear spaces, completeness, limits, iteration of limits, differentiation of vector functions. 415: Integration on the line, multiple integrals, Green's theorem. 416: Topics include manifolds, summability theory, integration theory, approximation theory, function algebras, Fourier analysis, fixed-point theorem.

421. MATHEMATICAL LOGIC.
(3-0) Cr. 3. F.S.
Prerequisite: 301 or Phil. 370.
Validity, provability, consistency, completeness, definability, and decision problems for propositional calculus, predicate calculus, and generalized mathematical theories.

436, 437. PROJECTIVE GEOMETRY.
(3-0) Cr. 3 each. 436: W; 437: S.
Prerequisite: 202.
Projective properties studied by synthetic and analytic methods.

450. NUMBER THEORY.
(3-0) Cr. 3. S.
Prerequisite: 301.
Properties of the integers. Diophantine equations, prime number distribution and representation problems.

489. HISTORY OF MATHEMATICS.
(3-0) Cr. 3. F.
Prerequisite: 112.
Sources and growth of mathematical knowledge, contributions of outstanding mathematicians. Offered on satisfactory-fail basis only.

490. SPECIAL PROBLEMS.
Cr. 1 to 3 each time taken.
Prerequisite: 202.

497. TEACHING OF SECONDARY SCHOOL MATHEMATICS.
(3-0) Cr. 3. W.
Prerequisite: Twenty-two credits in college mathematics.
Organization of subject matter, methods of presenting particular topics, evaluation of results.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

504, 505, 506. ABSTRACT ALGEBRA.
(3-0) Cr. 3 each. Yr. SS.
Prerequisite: 302.
Algebraic systems and their morphisms including groups, rings, fields, modules, and categories.

507, 508. NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS.
(Com.S. 507, 508) (3-0) Cr. 3 each. 507: F; 508: W.
Prerequisite: 408 or 410 or 415.
One-step methods for initial value problems, one-step methods for systems, multi-step methods, boundary value problems. Examples using University computers.

509. COMPUTATIONAL METHODS OF LINEAR ALGEBRA.
(Com.S. 509) Cr. 3. S.
Prerequisite: 303 or 307.
Numerical methods involved in the solution of linear systems, matrix inversion, eigen-value problems (symmetric and nonsymmetric); completion method, ill-conditioned matrices; linear inequalities. Examples using University computers.

511, 512, 513. FUNCTIONS OF A SINGLE COMPLEX VARIABLE.
(3-0) Cr. 3 each. Yr.SS.
Prerequisite: 410 or 415.
Topological concepts for extended complex plane, analytic functions, conformal mappings, integration, power series, Laurent series. Cauchy residue theorem, evaluation of real integrals, harmonic functions, analytic continuation.

514, 515, 516. REAL ANALYSIS.
(3-0) Cr. 3 each Yr.SS.
Prerequisite: 415.
Basic concepts of topological spaces, function spaces, measure and integration.

521, 522, 523. APPLIED MATHEMATICS.
(3-0) Cr. 3 each. Yr.SS.
Prerequisite: 322, 411.
Linear partial differential equations, boundary value problems, maximum principles, Green's functions, separation of variables, Sturm-Liouville problems, integral transforms.

524, 525. THEORY OF AUTOMATA.
(Com.S. 524, 525) (3-0) Cr. 3 each. 524: W; 525: S.
Prerequisite: 421.
Various notions and formalizations of computability and their comparison. Turing machines, Markov algorithms, recursive functions, unsolvability results, finite automata, sequential machines, synthesis and decomposition of abstract machines.

528, 529. SPECIAL FUNCTIONS.
(3-0) Cr. 3 each. 528: F; 529: W.
Prerequisite: 411.
Infinite products, asymptotic series, Gamma and Beta functions, hypergeometric functions, generalized and confluent hypergeometric functions, Bessel and Legendre functions, generating functions, orthogonal polynomials, elliptic functions.

531, 532, 533. INTRODUCTION TO FUNCTIONAL ANALYSIS.
(3-0) Cr. 3 each. Yr.
Prerequisite: Permission of instructor.
Fundamental theory of normed linear spaces and algebras emphasizing aspects which provide a framework for study of boundary-value problems, eigen-value problems, harmonic analysis and analytic function theory. Hahn-Banach theorem, Banach-Steinhaus theorem, Gelfand representation, elementary spectral theory for operators in Hilbert space.

534, 535, 536. TOPOLOGY.
(3-0) Cr. 3 each. Yr.
Prerequisite: 333.
Introduction to general topology and homotopy theory.

537, 538, 539. ALGEBRAIC TOPOLOGY.
(3-0) Cr. 3 each. Yr.
Prerequisite: 302, 333.
Foundations of algebraic topology. Homotopy and homology groups, fibrations, applications to manifolds.

554, 555. PROBABILITY.
(Stat. 554, 555) (3-0) Cr. 3 each. 554: W; 555: S.
Prerequisite: Stat. 541.
Occupancy problems and combinations of events, generating functions, branching processes, recurrent events, Markov chains, queueing theory, Markov processes, general one-dimensional random walk.

557, 558, 559. ORDINARY DIFFERENTIAL EQUATIONS.
(3-0) Cr. 3 each. Yr.
Prerequisite: 213; 303 or 307; 410 or 415.
The initial-value problem, existence and uniqueness theorems, linear systems, stability and asymptotic behavior of solutions, dynamical systems, two-point boundary-value problems.

562, 563. DIFFERENTIAL GEOMETRY.
(3-0) Cr. 3 each. Alt. W. and S, offered 1972.
Prerequisite: Permission of instructor.
Differentiable manifolds, local and global properties of curves and surfaces in Euclidean spaces.

564, 565, 566. THEORY OF GROUPS.
(3-0) Cr. 3 each. Alt.Yr, offered 1972-1973.
Prerequisite: 505.
Commutators, transfer, p-groups, nilpotent groups, solvable groups, permutation groups, free groups, semidirect products, extension theory, introduction to representations and characters.

567. BOOLEAN RINGS.
(3-0) Cr. 3. SS.
Prerequisite: Permission of instructor.
Structure of semi-simple commutative rings and their representation. Atomicity and completeness. Stone space of Boolean rings. The field of Borel and Baire sets. Theorems on extension of homomorphisms. Applications to mathematical logic and measure theory.

571, 572, 573. MATHEMATICAL LOGIC.
(3-0) Cr. 3 each. Yr.
Prerequisite: 421.
Algebraic structures in logical systems, recursive functions, consistency, undecidability and incompleteness of axiomatic theories, results of Gentzen and Gödel, theory of models, ultraproducts and ultralimits, nonstandard analysis.

581, 582, 583. AXIOMATIC SET THEORY.
(3-0) Cr. 3 each. Yr.
Prerequisite: Permission of instructor.
Axiomatic considerations, model and proof theory, Zermelo-Fraenkel axioms, classical theorems, transfinite methods, ordinal and cardinal numbers and their arithmetic. Von Neuman—Bernays—Gödel axioms, inaccessible cardinals, consistency and independence results of Gödel, Cohen and others.

584, 585, 586. HOMOLOGICAL ALGEBRA.
(3-0) Cr. 3 each. Alt. Yr, offered 1971-1972.
Prerequisite: 505.
Exact sequences, homology, functors Hom, Tor, Ext, Künneth formula, relative homological algebra, cohomology of algebraic systems.

587, 588, 589. INTRODUCTION TO INTEGRATION THEORY AND APPLICATIONS.
(3-0) Cr. 3 each. Yr.
Prerequisite: Permission of instructor.
Topics in modern integration theory including integration of vector functions, integration with respect to finitely additive measures, theory of vector measures. Applications to problems in functional analysis.

590. SPECIAL TOPICS.
Cr. var.

COURSES FOR GRADUATE STUDENTS, major or minor

604. ADVANCED TOPICS IN ABSTRACT ALGEBRA.
(3-0) Cr. 3 each time taken. W.S.
Prerequisite: 506.
Associative or nonassociative algebras, groups, rings, fields, local algebras, categorical algebras.

607. ADVANCED TOPICS IN NUMERICAL ANALYSIS.
(Com.S. 607) (3-0) Cr. 3. S.
Prerequisite: 523; 508 and 509, or 408.
Stability and error analysis, numerical solution of partial differential equations, successive overrelaxation methods, research work using University computers.

610. SEMINAR.

611. ADVANCED TOPICS IN THE THEORY OF FUNCTIONS OF A SINGLE COMPLEX VARIABLE.
(3-0) Cr. 3 each time taken. F.W.S.
Prerequisite: 512, 536.
The Riemann sphere, conformal mappings, topological indices, Cauchy integral formulas, power series, Laurent series, local mapping theorems, harmonic functions, the Poisson integral formula, the Dirichlet problem, the Mittag-Leffler theorem, special functions.

615. ADVANCED TOPICS IN FOUNDATIONS OF MATHEMATICS.
(3-0) Cr. 3 each time taken. F.W.S.
Prerequisite: Permission of instructor.
Topics selected from mathematical logic, recursive function theory, model theory, and set theory.

621. ADVANCED TOPICS IN PARTIAL DIFFERENTIAL EQUATIONS.
(3-0) Cr. 3 each time taken. F.W.S.
Prerequisite: 511, 521.
Maximum principles, pointwise bounds, conservation equations, distributions, Hilbert space.

634. ADVANCED TOPICS IN TOPOLOGY.
(3-0) Cr. 3 each time taken. F.W.S.
Prerequisite: 536.
Topics selected from dimension theory, topology of manifolds, homotopy and homology theory, structure of continua.

657. ADVANCED TOPICS IN ORDINARY DIFFERENTIAL EQUATIONS.
(3-0) Cr. 3 each time taken. F.W.S.
Prerequisite: Permission of instructor.
Selected topics from the theory of ordinary differential equations.

690. SPECIAL TOPICS.
Cr. var.
Prerequisite: Permission of instructor.
A. Algebra.
B. Functional Analysis.
C. Measure Theory.
D. Approximation Theory.
E. Linear Algebra.
F. Calculus of Variations.
T. Topology.

699. RESEARCH.

MECHANICAL ENGINEERING

Henry M. Black, S.M., Head of Department

The Graduate Faculty

Members: H.M. Black, B.L. Johnson, C.R. Mischke, G.K. Serovy

Associate Members: W.J. Cook, R.C. Fellinger, R.W. Fisher, J.L. Hall, A. Henkin, G.H. Junkhan, P. Kavanagh, T.H. Okiishi, L.C. Peters, R.H. Pletcher

The department offers work for the degrees Master of Science and Master of Engineering with major in mechanical engineering, and minor work to students taking major work in other departments. Work may be taken for the degree Doctor of Philosophy as a joint major with departments offering work in related fields.

Students desiring to major in this department should have completed an undergraduate curriculum equivalent to that required of undergraduate students in mechanical engineering at this institution.

The requirements for advanced degrees, including foreign languages, are controlled by the student's advisory committee. There is no foreign language requirement for the degree Master of Engineering. For the degree Master of Science, the language requirement is at the discretion of the student's advisory committee. Candidates who expect to pursue doctoral work can anticipate a single language proficiency equivalent to one year of classroom preparation. The language requirement for the degree Doctor of Philosophy is also at the discretion of the student's advisory committee. Candidates can expect to demonstrate a high degree of competence in one language or a satisfactory reading competence in two languages. Approved languages are German, French, or Russian. English may be approved in the case of a student whose native tongue is not English.

COURSES FOR GRADUATE STUDENTS, minor only

321. THERMODYNAMICS I.
(4-0) Cr. 4. F.W.
Prerequisite: Math. 213, Phys. 222.
Properties and fundamental equations for states and processes involving gases, vapors, and gas mixtures.

322. THERMODYNAMICS II.
(3-0) Cr. 3. W.S.
Prerequisite: 321.
Air tables, compressible flow, compressors and turbines, air standard cycles for engines and turbines.

323. THERMODYNAMICS III.
(3-0) Cr. 3. F.S.
Prerequisite: 322.
Vapor power cycles, refrigeration, property relations, and processes for real gases. Gas mixtures with constant and variable specific heats. Psychrometry and introduction to air conditioning processes.

324. THERMODYNAMICS IV.
(3-0) Cr. 3. F.W.
Prerequisite: 323.
Third Law, absolute entropy of gas mixtures. Material balances for combustion. Thermochemistry and gas phase equilibrium. Energy balances.

331. MECHANICAL METALLURGY.
(Met. 331) (3-2) Cr. 4. F.W.SSI.
Prerequisite: Met. 230, E.M. 325.
Application of the basic principles of structure of solids to the study and control of mechanical properties of metals. Qualitative and quantitative relationships between the microstructure and mechanical properties. Ferrous and nonferrous systems.

332, 333. MANUFACTURING PROCESSES I, II.
(Met. 332, 333) (3-2) Cr. 3 each. 332: W.S. SSII; 333: F.S.
Prerequisite: 332: 331; 333: 332.
The relationship between material properties, manufacturing process, and product properties. The basic processes (casting, welding, forming and machining) and the functional characteristics of equipment. Manufacturing considerations in design.

411. INDUSTRIAL AUTOMATIC CONTROLS.
(2-2) Cr. 3. F.S.
Prerequisite: 422.
Methods and principles of automatic control. Pneumatic, hydraulic, and electrical systems. Representative applications of automatic control systems. Mathematical analysis of control systems.

416. ENGINEERING SYSTEMS ANALYSIS.
(3-3) Cr. 4. S.
Prerequisite: 422, 425, E.E. 442.
The application of fundamental concepts from several areas to the solution of engineering problems. Mathematical statement of the problem. Introduction to analogies and dimensional analysis in problem solution. Analog and digital computing methods.

420, 421, 422. MACHINE DESIGN I, II, III.
420: (4-0) Cr. 4. F.S.SSI; 421: (3-0) Cr. 3. F.W.SSII; 422: (3-0) Cr. 3. W.S.SSI.
Prerequisite: 420: 235 or 332; Math. 321, E.M. 325, 345; 421: 420; 422: 421.
Theory of machines. Kinematics and dynamics of mechanisms, design and selection of machine elements, vibratory phenomena, introduction to automatic control theory.

423. **MECHANICAL SYSTEMS DESIGN.**
(1-9) Cr. 4. F.S.SSI.
Prerequisite: 422.
Solution of total design problems involving the use of basic engineering concepts and industrial practices.

424, 425. **FLUID FLOW AND HEAT TRANSFER.**
424: (3-2) Cr. 4. W.S.SSI; 425: (4-0) Cr. 4. F.W.SSII.
Prerequisite: E.M. 345, Math. 321, credit or classification in M.E. 322.
424: Kinematics and dynamics of ideal and real fluids. Energy and momentum relations. Similarity in fluid systems. Real fluid effects. 425: Principles of the transfer of heat by conduction, convection and radiation. Analytical and experimental methods for determination of coefficients. Introduction to problems involving diffusion and mass transfer.

426. **REFRIGERATION AND AIR CONDITIONING.**
(3-0) Cr. 3. F.W.
Prerequisite: 325 or 425.
Principles of refrigeration; analysis of refrigeration cycles. Principles of air conditioning with emphasis on thermodynamic processes involving air-water vapor mixtures.

427. **HEATING AND AIR CONDITIONING DESIGN.**
(2-6) Cr. 4. S.
Prerequisite: 426.
Design and layout of heating, ventilation, and air conditioning systems.

428. **REFRIGERATION.**
(3-0) Cr. 3. S.
Prerequisite: 426.
Fundamentals of vapor compression refrigeration; multi-pressure cycles. Absorption refrigeration. Air cycles. Refrigerants. Cryogenics. Steam jet refrigeration. Thermoelectric cooling. Reversed cycles.

429. **INTERNAL COMBUSTION ENGINE DESIGN.**
(2-6) Cr. 4. S.
Prerequisite: 445, credit or classification in 423.
Design and layout of a high-speed internal combustion engine of carburetion or diesel type.

444. **STEAM POWER PLANTS.**
(3-0) Cr. 3. W.S.
Prerequisite: 425, 324.
Thermodynamics and performance of boilers, turbines, pumps, heat exchangers, and other power plant equipment. Efficiency and economy of modern stations and their cycles.

445. **INTERNAL COMBUSTION ENGINES.**
(3-0) Cr. 3. W.S.SSI.
Prerequisite: 324, credit or classification in 425.
General principles, thermodynamics, and performance of carburetion and fuel-injection engines. Characteristics of fuels.

448. **STEAM POWER PLANT DESIGN.**
(2-6) Cr. 4. S.
Prerequisite: 444.
Principal and auxiliary equipment for power, heating, and pumping plants. Cooling towers, boiler water treatment, principles of plant design.

461. **ENGINEERING MEASUREMENTS I.**
(2-3) Cr. 3. F.W.
Prerequisite: 420, E.E. 442.
Fundamentals of design, selection and operation of instrumentation components of measuring systems.

462. **ENGINEERING MEASUREMENTS II.**
(1-6) Cr. 3. W.S.
Prerequisite: 252, 461.
ASME Power Test Codes and ASTM Standard Test Procedures applied to selected areas of measurement; use of analogies and similitude in engineering experimentation, advanced engineering measurements, presentation of formal reports.

470. **COMPUTER-AIDED DESIGN.**
(3-0) Cr. 3. S.
Prerequisite: Elementary knowledge of FORTRAN.
An examination of the morphology of design processes, the structure of the FORTRAN language, figures of merit, searching and optimization techniques leading to an algorithmic approach to design.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

501. **DESIGN OF ENGINEERING EXPERIMENTS I.**
(2-3) Cr. 3. F.
Prerequisite: 252 or Stat. 401.
Fundamentals of design, selection, and operation of instrumentation components of measuring systems. Techniques for the analysis, interpretation, and presentation of experimental data. Error analysis and propagation of error.

502. **DESIGN OF ENGINEERING EXPERIMENTS II.**
(3-0) Cr. 3. W.
Prerequisite: 501.
Planning of experimental programs and design of experiments to obtain data such that results are within prescribed limits of precision.

513. **LUBRICATION AND FRICTION.**
(4-0) Cr. 4. W.
Prerequisite: 420, 424.
Theories of lubrication and friction and their application to design.

515. **ADVANCED DESIGN.**
(4-0) Cr. 4. W.
Prerequisite: E.M. 514.
Experimental, empirical, and rational methods of analysis and synthesis in the solution of advanced design problems.

516. **ADVANCED KINEMATICS OF MECHANISMS.**
(3-0) Cr. 3. F.
Prerequisite: 421.
Analysis of simple and complex mechanisms. Goodman's and Carter's methods; auxiliary-point and normal acceleration methods. Advanced kinematics of plane motion; Euler-Savory equation, inflection circle, polode curvature, the cubic of stationary curvature.

517. **KINEMATIC SYNTHESIS OF MECHANISMS.**
(2-0) Cr. 2. W.
Prerequisite: 516.
Synthesis of mechanisms; graphical, analytical, and graphical-analytical methods.

521. **INTERMEDIATE TOPICS IN THERMODYNAMICS.**
(3-0) Cr. 3. F.
Prerequisite: 322 or 344.
Students may not receive credit in both 521 and 621. General equations for properties of the pure substance. Third law and absolute entropy. Real gas equations of state. Processes involving real gas effects.

523. THERMODYNAMICS OF COMPRESSIBLE FLOW I.
(4-0) Cr. 4. W.
Prerequisite: 321 or 344; 424 or E.M. 378.
Thermodynamics of high-velocity flow within enclosed channels. Basic one-dimensional flow relations. The Mach parameter. Effects of friction and plane shocks. Fanno and Rayleigh lines, diabatic flow. Theory and use of gas tables.

524. THERMODYNAMICS OF COMPRESSIBLE FLOW II.
(Aero.E. 524) (4-0) Cr. 4. S.
Prerequisite: 523.
Generalized one-dimensional steady internal flow. Theory and application of one-dimensional unsteady compressible flow.

525. HEAT TRANSFER.
(4-0) Cr. 4. W.
Prerequisite: 425 or equivalent.
Intermediate-level treatment of heat transmission by conduction, convection, and radiation. Intended for those who require a general coverage of theory and methods but whose primary research interests are in other areas.

540. ADVANCED COMBUSTION.
(3-0) Cr. 3. Alt. W, offered 1972.
Prerequisite: 324.
Theories of the mechanism of combustion. Flame temperatures, speed and propagation. Explosive limits of fuel-air mixtures. Nozzles and flow passages for chemically reacting gases.

541, 542, 543. ADVANCED AERODYNAMICS.
(Aero.E. 541, 542, 543) See Aerospace Engineering.

544. PRINCIPLES OF TURBOMACHINERY.
(4-0) Cr. 4. F.
Prerequisite: 322, 424.
Application of the concepts and methods of fluid mechanics and thermodynamics to the analysis of flow in turbomachinery components.

545. FLIGHT PROPULSION SYSTEMS.
(Aero.E. 545) (3-0) Cr. 3. S.
Prerequisite: 523, and 544 or Aero.E. 413.
Analysis and selection of propulsion systems for flight vehicles. Optimization of components and design parameters for atmospheric flight and for power and thrust generation in space.

549. EXPERIMENTAL GAS DYNAMICS AND SHOCK TUBE THEORY.
(Aero.E. 549) (2-3) Cr. 3. S.
Prerequisite: 523.
Theory of shock tube operation for the production of shock waves with the corresponding high-temperature, high-velocity gas flows. Instrumentation for the measurement of thermodynamic properties, heat transfer, shock-wave velocity, and boundary-layer phenomena in shock tubes.

571, 572, 573. ADVANCED FLUID MECHANICS.
(E.M. 571, 572, 573) See Engineering Mechanics.

590. SPECIAL TOPICS.
Cr. 2 to 8.
Investigation of problems of special interest to graduate students in mechanical engineering. Election of course and problem must be approved in advance.
A. Special course study.
B. Independent literature investigation. Comprehensive report required.

COURSES FOR GRADUATE STUDENTS, major or minor

600. ADVANCED MACHINE DESIGN.
(3-0) Cr. 3. S.
Prerequisite: Permission of instructor.
Mathematical and experimental analysis of problems in field of dynamics of machinery, stress analysis, and vibration. Choice of work any quarter determined by aptitudes and interests of class.

610. DYNAMICS OF FLUID CONTROL SYSTEMS.
(3-0) Cr. 3. W.
Prerequisite: 411, 424.
Dynamical characteristics of fluid control systems and elements.

620. SEMINAR.
(1-0) Cr. 1. F.

621, 622. ADVANCED ENGINEERING THERMODYNAMICS.
(4-0) Cr. 4 each. Alt. S; 621: Offered 1972; 622: Offered 1973.
Prerequisite: Permission of instructor.
Fundamental concepts of thermodynamics, thermodynamic laws, temperature, entropy, general thermodynamic equations, properties of steam, availability, equilibrium. Thermodynamics of thermoelectricity. Special topics.

623, 624. MAGNETOFLUIDMECHANICS AND PLASMA DYNAMICS.
(Aero.E. 623, 624) See Aerospace Engineering.

625. ADVANCED HEAT TRANSFER I.
(3-0) Cr. 3. Alt. F, offered 1972.
Prerequisite: 425 or equivalent.
Techniques for the analysis of problems involving steady-state and transient heat conduction in solids.

626. ADVANCED HEAT TRANSFER II.
(3-0) Cr. 3. Alt.W, offered 1973.
Prerequisite: 425 or equivalent.
The boundary layer concept and its relation to convective heat transfer. Methods for analysis of the convection process in internal and external flow.

627. ADVANCED HEAT TRANSFER III.
(3-0) Cr. 3. Alt.S, offered 1973.
Prerequisite: 425 or equivalent.
Transfer of energy by thermal radiation.

642. ADVANCED PROBLEMS IN TURBOMACHINERY.
Cr. 2 to 4. Alt. W, offered 1973.
Prerequisite: 544.
Three-dimensional flow in turbomachinery. Blade selection and passage design. Analysis of experimental results with special emphasis on real fluid effects and off-design performance.

650. FLUID MECHANICS SEMINAR.
(Aero.E. 650) (E.M. 650) See Aerospace Engineering.

699. RESEARCH.

METALLURGY

Monroe S. Wechsler, Ph.D., Chairman of Department

The Graduate Faculty

Members: O.N. Carlson, C.W. Chen, P. Chiotti, K.A. Gschneidner, F.X. Kayser, W.L. Larsen, W.H. McCorkle, D.T. Peterson, T.E. Scott, J.F. Smith, F.H. Spedding, R.K. Trivedi, J.D. Verhoeven, M.S. Wechsler, H.A. Wilhelm

Associate Member: J.W. Patterson

The department offers work for the degrees Master of Science and Doctor of Philosophy with major in metallurgy. Minor work is available to students taking major work in other departments.

Prerequisite to graduate study in metallurgy is completion of an undergraduate curriculum in metallurgy or metallurgical engineering or in a closely allied field such as materials engineering or science, physics, chemistry, ceramic engineering, chemical engineering, or mechanical engineering. Students majoring in metallurgy will usually choose supporting course work in these or similar allied fields.

No foreign language is required for the degree Master of Science. Before admission to candidacy for the degree Doctor of Philosophy, the student is required to demonstrate his proficiency in either French, German, or Russian by attaining a score of 600 for French or 525 for German or Russian in the Educational Testing Service examination. After satisfying the requirement, the student must translate one journal article per quarter for three consecutive quarters; the articles will be chosen and the translation approved by the major professor.

Excellent facilities are provided by the Department of Metallurgy and the Institute for Atomic Research for investigations in theoretical and applied fields of metallurgy.

COURSES FOR GRADUATE STUDENTS, minor only

301, 302, 303. PHYSICAL METALLURGY.
(4-0) Cr. 4 each. Yr.
Prerequisite: 230 or 231.
301: Stereography, X-ray diffraction, basic dislocation theory, deformation of metals. 302: Grain boundaries, grain growth, vacancies, diffusion, nucleation, solidification, recovery, and recrystallization. 303: Solid solutions, precipitation hardening, twinning and martensite reactions, transformation kinetics, strengthening processes.

305, 306, 307. PHYSICAL METALLURGY LABORATORY.
(0-6) Cr. 2 each. Yr.
To be taken concurrently with sequence 301, 302, 303. Experiments in X-ray diffraction, measurement of physical properties, pyrometry, heat treatment, metallography, mechanical testing.

360. METALLURGICAL THERMOCHEMISTRY.
(3-0) Cr. 3. W.
Prerequisite: Chem. 321.
Concepts of fugacity, activity, activity coefficient, and the equilibrium constant. Thermodynamic description of solutions and unary and binary phase boundaries. Reaction kinetics, the electrochemistry of solid and liquid electrolytes and an introduction to corrosion theory.

361. CHEMICAL METALLURGY.
(3-0) Cr. 3. S.
Prerequisite: Math. 213, Phys. 222, Chem. 142, 142L.
Principles of fluid flow, heat and mass transfer. Applications to solidification, furnace design, pyrometry, reactions at metal surfaces and kinetics of metallurgical processes.

401, 402. MECHANICAL BEHAVIOR OF METALS.
(3-0) Cr. 3 each. 401: F; 402: W.
Prerequisite: 303.
Elasticity and plasticity, applications to metallurgical problems and materials testing. Fracture, fatigue, and residual stresses. Advanced metal-processing technology.

410. PHYSICAL METALLURGY.
(4-0) Cr. 4. F.
Prerequisite: Permission of instructor.
An introduction to physical metallurgy for advanced students in science or engineering who have little or no prior preparation in metallurgy. Not open for credit to students majoring in metallurgy.

433. METALLURGICAL ENGINEERING DESIGN.
(3-0) Cr. 3. S.
Prerequisite: 402.
The application of physical, chemical, and mechanical metallurgical principles to the design of metal parts and processes.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

501, 502, 503. ADVANCED PHYSICAL METALLURGY.
(3-0) Cr. 3 each. Yr.
Prerequisite: 303 or 410.
501: Point defects, defect interactions, mechanisms of defect migration. Solid state diffusion, random walk treatment. Phenomenological diffusion theory. Free energy diagrams. Reaction rate theory, thermally activated processes. Applications to recovery, recrystallization, grain growth and spinodal decomposition. 502: Nucleation theory. Principles of solidification. Analysis of the eutectoid transformation. Theory of age hardening, relation to mechanical properties. Defect theory of recrystallization. 503: Atomic displacements and atomic distributions in solid solutions, order-disorder transformations, the properties of ordered alloys. Thermodynamics and crystallography of the martensite transformation. Twinning. Bainite and massive transformation, tempering.

512. INTRODUCTORY METAL THEORY.
(3-0) Cr. 3. F.
Prerequisite: Credit or classification in Math. 409.
Free electron theory and band theory. Brillouin zones and Fermi surfaces, electronic conductivity and scattering processes, magnetic behavior, electronic and lattice heat capacities, cohesion and elastic constants.

532. STRUCTURE AND PROPERTIES OF STEEL.
(3-0) Cr. 3. S.
Prerequisite: 303, and 331 or 410.
Application of fundamental concepts of phase transformations, mechanical behavior, and heat flow to the problems of heat treatment and selection of steels.

540. THEORY OF DISLOCATIONS.
(3-0) Cr. 3. F.
Prerequisite: Credit or classification in Math. 409.
Theory of dislocations based on linear elasticity. Self and interaction energies of dislocations. The concept of forces on dislocations and their calculations; line tension, image, chemical and Peierls forces.

541. APPLICATIONS OF DISLOCATION THEORY.
(3-0) Cr. 3. W.
Prerequisite: 540.
Dislocations treated from the geometric viewpoint. Partial dislocations, stacking faults, and pile-ups; dislocation generation, multiplication, point-defect production, dislocation networks and boundaries. Concepts applied to strengthening mechanisms and deformation.

555. X-RAY DIFFRACTION.
(3-0) Cr. 3. W.
Prerequisite: 301 or 410.
Kinematical diffraction theory, dispersion-corrected scattering factors, the Debye-Waller factor, refraction and extinction. Applications of Debye-Scherrer and diffractometer methods, and neutron and electron diffraction.

557. X-RAY DIFFRACTION LABORATORY.
(0-6) Cr. 2. S.
Prerequisite: 555.
Determination of the orientation of single crystals, crystal structure, lattice parameters, particle sizes, long-range order parameters, residual stresses, phase boundaries in alloys and retained austenite. Statistical methods of error analysis and computer programmed solutions.

561. PRINCIPLES OF CHEMICAL METALLURGY.
(3-0) Cr. 3. F.
Prerequisite: Chem. 321.
Occurrence and production of metals, including the less common metals. Analysis of the economic, stoichiometric, and thermodynamic principles in chemical metallurgy.

562. PRINCIPLES OF METALLURGICAL THERMODYNAMICS.
(3-0) Cr. 3. F.
Prerequisite: Chem. 321, Math. 213.
Classical thermodynamics, consequences of the three laws, application and the mathematical basis for the description of homogeneous and heterogeneous equilibria and phase relations in unary and multicomponent systems.

563. APPLICATIONS OF METALLURGICAL THERMODYNAMICS.
(3-0) Cr. 3. W.
Prerequisite: 562.
Solubility of gases in metals, oxidation of metals and alloys, thermochemistry of steelmaking, atmosphere control with gas mixture, special applications of Clausius-Clapeyron equation, use of Richardson and Jeffes charts, thermodynamics of alloys and interaction coefficients.

571. CORROSION AND OXIDATION.
(3-0) Cr. 3. F.
Prerequisite: 360 or Chem. 323.
A study of the origin, development, and current applicability of theories of corrosion and oxidation of metals.

590. SPECIAL TOPICS IN METALLURGY.
Cr. arr.
Prerequisite: Permission of instructor.
Topics of current interest in metallurgy.

COURSES FOR GRADUATE STUDENTS, major or minor

610, 611. ALLOY THEORY.
(3-0) Cr. 3 each. Alt.F; 610 offered 1972; 611 offered 1971.
Prerequisite: 512.
Cohesion and bonding in matter; their relationship to structure, thermodynamics, other physical properties, and the factors affecting alloying behavior of metals. 610: Emphasis on solid solutions and liquid alloys. 611: Emphasis on intermetallic phases.

640. OBSERVATIONS OF DEFECTS IN CRYSTALS.
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: 541.
Transmission electron microscopy and its application to the study of dislocations, precipitates, clusters of point defects, stacking faults, and magnetic and antiphase domain boundaries. Electron diffraction and Moire patterns. Field-ion microscopy

655. X-RAY SCATTERING FROM CRYSTALS.
(2-0) Cr. 2 each time taken. Alt.F, offered 1971.
Prerequisite: Math. 555 or permission of instructor.
Selected topics including temperature diffuse scattering, the Debye-Waller factor, short- and long-range order, stacking faults in metals, extinction effects, dynamical theory of diffraction.

662. **ADVANCED TOPICS IN METALLURGICAL THERMODYNAMICS.**
Cr. 2 to 3 each time taken. Offered on request.
Prerequisite: 562.
Thermodynamics of irreversible processes. Research on the application of thermodynamics to physical metallurgy. Statistical thermodynamics and its application to metallurgical processes.

691. **METALLURGY SEMINAR.**
Cr. arr.

699. **RESEARCH.**

NUCLEAR ENGINEERING

Glenn Murphy, Ph.D., Head of Department

The Graduate Faculty

Members: R.A. Danofsky, B.M. Ma, G. Murphy, D.M. Roberts

Associate Members: P.W. Barcus, H. Bell, V.D. Chitnis, R.T. Greer, R.A. Hendrickson, W.D. Leech, M.R. Ringham, A.F. Rohach

The department offers work for the degrees Master of Science, Master of Engineering, and Doctor of Philosophy with major in nuclear engineering. Minor work in nuclear engineering and in engineering similitude is offered to students taking major work in other departments.

Prerequisite to major work is the completion of a curriculum substantially equivalent to that required of undergraduate students in engineering at this institution. It is recommended that students contemplating graduate studies in nuclear engineering include courses in modern physics, heat transfer, chemistry beyond freshman chemistry, and mathematics beyond differential equations as part of their undergraduate preparation.

A foreign language is not required for the degrees Master of Science or Master of Engineering. For the degree Doctor of Philosophy a reading knowledge of one foreign language is required. This requirement may be met by (1) attaining a minimum grade of B in 15 credits of foreign language at the collegiate level, or (2) demonstrating in a departmental examination a reading knowledge of a foreign language in the student's field of specialization.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

501. **ELEMENTS OF NUCLEAR ENGINEERING.**
(3-0) Cr. 3. F.
Prerequisite: M.E. 321 or 344.
Technical problems of nuclear power utilization and control. Shielding. Isotope utilization.

502. **NUCLEAR REACTOR MATERIALS.**
(3-0) Cr. 3. W.
Prerequisite: 501 and permission of instructor.
Mechanical and nuclear properties of solid, fluid, and gaseous reactor materials. Radiation effects.

503. **NUCLEAR REACTOR MATERIALS.**
(3-0) Cr. 3. S.
Prerequisite: 502.
Mechanical and nuclear properties of solid and fluid reactor materials. Thermal and structural problems in reactors.

504. **NUCLEAR REACTOR DESIGN.**
(1-6) Cr. 3. S; or (3-15) Cr. 8. 12 wk. SS.
Prerequisite: Credit or classification in 537.
Engineering aspects of reactor design and use of nuclear power.

506. **ADVANCED PROPERTIES OF ENGINEERING MATERIALS.**
(3-0) Cr. 3. F.
Prerequisite: E.Sci. 351.
Influence of structure and environment on the mechanical properties of engineering materials. Types of imperfections and their effects. Control of properties.

507. **RADIATION SAFETY.**
(3-0) Cr. 3. W.
Prerequisite: Permission of instructor.
Sources and nature of radiation, measurement techniques, somatic and genetic effects, AEC regulations, and safety procedures.

510. **NUCLEAR RADIATION MEASUREMENTS.**
(1-4) Cr. 3. W.
Principles of nuclear radiation detection and measurement. Ionization chambers, proportional counters, geiger tubes. Counting circuits. Applications to engineering problems.

511. **NUCLEAR FUELS AND WASTES.**
(3-0) Cr. 3. S.
Prerequisite: Permission of instructor.
Preparation of reactor fuels and handling of radioactive wastes.

512. **REPROCESSING NUCLEAR FUELS.**
(3-0) Cr. 3. SS.
Prerequisite: 511.
Principles of nuclear reprocessing methods.

517, 518, 519. **ANALYTICAL METHODS IN NUCLEAR ENGINEERING.**
(3-0) Cr. 3 each. Yr.
Prerequisite: 517: Math. 322; 518: 517; 519: 518.
517: Method of attack on engineering problems. Appropriate physical laws and application of mathematics. Series expansions, averages, elementary vector and matrix methods. 518: Problem formulation in differential form. Solutions. Vector and matrix methods. Finite difference methods. Calculus of variations. 519: Problem formulation in integral form. Integral equations, variational methods, and introduction to optimization.

524. **NUCLEAR POWER ECONOMICS.**
(3-0) Cr. 3. S.
Prerequisite: 501.
Economics of direct-cycle and indirect-cycle nuclear reactor systems, fuel cells, direct conversion. Comparisons with wind, tidal, solar, geothermal, hydrothermal, and fossil fuels. Direct secondary effects.

534. **REACTOR STRESS ANALYSIS.**
(3-0) Cr. 3.
Prerequisite: E.M. 324, Math. 321.
Analysis of stresses in reactor elements and structures. Thermal stresses in fuel elements and reactor vessels. Design of containment structures.

535. **NUCLEAR PHYSICS FOR ENGINEERS.**
(4-0) Cr. 4. F.
Prerequisite: Math. 321, Phys. 223.
Atomic and nuclear structure, introduction to quantum theory, fundamental particles; isotopes; alpha, beta and gamma radiation.

536, 537. **ELEMENTARY REACTOR THEORY.**
(3-0) Cr. 3 each. W.S.
Prerequisite: 535 or Phys. 483 or 593; Math. 322.
Diffusion of neutrons, homogeneous and heterogeneous reactors, reactor control, perturbation theory, and transport theory.

540. **ANALYSIS OF DYNAMIC SYSTEMS.**
(3-2) Cr. 4. F.
Prerequisite: E.M. 345, Math. 321.
Dynamic performance of engineering systems with emphasis on aperiodic conditions. Transient response of open-loop and closed-loop systems. Dynamic performance of mechanical, fluid, and electrical components. Use of analog computer to obtain dynamic response.

541, 542, 543. **REACTOR LABORATORY.**
(1-6) Cr. 3 each. F.W.S.
Prerequisite: 510.
Laboratory problems involving the nuclear reactor.

554. **RADIOISOTOPES IN ENGINEERING.**
(2-4) Cr. 4. F.
Prerequisite: Permission of instructor.
Principles of industrial utilization of radioisotopes and applications in engineering.

561, 562. **NUCLEAR REACTOR DYNAMICS.**
(3-2) Cr. 4 each. W.S.
Prerequisite: 537, 540.
Principles of reactor control and operation. Reactor kinetics with time varying inputs, the reactor as a control element, reactor performance in a power plant system, stochastic methods for measurements of reactor parameters.

566. **NUCLEAR SAFETY.**
(3-0) Cr. 3. S.
Prerequisite: 561.
AEC regulations, safety analyses, assessments of magnitudes and consequences of nuclear incidents. Reactor siting, safeguards, containment.

571, 572. **THERMONUCLEAR THEORY.**
(3-0) Cr. 3 each. W.S.
Prerequisite: 536.
Principles of thermonuclear reactions and their control. Plasma stability. Applications.

581, 582, 583. **REACTOR ANALYSIS.**
581: (3-0); 582: (2-2); 583: (2-2) Cr. 3 each. Yr.
Prerequisite: 537, Math. 408.
Application of numerical-analysis techniques to thermal and fast reactors.

590. **SPECIAL TOPICS.**
(2 to 5-0) Cr. 2 to 5.

591, 592. **OCEAN ENGINEERING SIMULATION.**
(3-0) Cr. 3 each. W.S.
Prerequisite: E.Sci. 481 or 484.
Development of mathematical and laboratory models and analogs for the solution of nuclear engineering problems associated with the ocean environment. Coastal and harbor applications. Deep-sea applications.

COURSES FOR GRADUATE STUDENTS, major or minor

602. **RADIATION SHIELDING.**
(3-0) Cr. 3.
Prerequisite: 504, 510, 536.
Design of shielding systems for protection against gamma rays and neutrons. Applications to nuclear reactors, cooling systems, processing equipment and other engineering units.

606. **NUCLEAR REACTOR FUELS.**
(3-0) Cr. 3. Alt. W. as arr.
Prerequisite: 506.
Physical and mechanical properties of metallic, ceramic, liquid, and dispersion-type fuel elements. Effect of irradiation upon fissile materials. Fabrication, inspection, and testing of nuclear fuels. Optimization of burnup and dimensional stability.

611, 612, 613. **ADVANCED REACTOR THEORY.**
(3-0) Cr. 3 each. Yr.
Prerequisite: 537.
Advanced theory of nuclear reactors.

620. **SEMINAR.**
(2-0) Cr. 2. F.
Prerequisite: Permission of instructor.
Current literature in nuclear engineering.

624. **ADVANCED NUCLEAR ENGINEERING.**
(2-2) Cr. 3. F.
Prerequisite: 504 or permission of instructor.
Exploitation of new concepts in nuclear engineering. Reactor systems, thermonuclear developments, fission, fusion, and mass-energy transducers.

651, 652, 653. **INTERACTION OF MATERIALS AND RADIATION.**
(3-2) Cr. 4 each. Alt. Yr. as arr.
Prerequisite: 502, 536.
Interaction between alpha, beta, gamma and neutron radiation and materials; absorption and scattering processes, influence on properties, shielding.

654. SELECTED TOPICS IN RADIOISOTOPE PRODUCTION AND APPLICATIONS.
(3-0) Cr. 3 each. Alt. Yr. as arr.
Prerequisite: 554.
A series of one-term courses covering in depth such topics as radioisotope production, neutron activation analysis, neutron radiography, radioisotope power generating systems and tracer applications current in engineering research and development.

684, 685, 686, 687. SIMILITUDE IN ENGINEERING.
(2-2) Cr. 3 each. 684: F; 685: W; 686: S; 687: F.
Prerequisite: Permission of instructor.
Principles of dimensional analysis and their application to design of models. Design, testing, and interpretation of models. True and distorted models, linear and nonlinear models, analogies. Applications.

699. RESEARCH.

PHILOSOPHY

Richard J. Van Iten, Ph.D., Chairman of Department

The Graduate Faculty

Member: R.J. Van Iten

Associate Members: D.F. Haight, P. Hollenbach

COURSE FOR GRADUATE STUDENTS, minor only

321. THE OLD TESTAMENT.
(3-0) Cr. 3. F.W.
Prerequisite: 200.
Major books in the Old Testament within the framework of their historical background with particular attention to the development of the great religious and ethical ideas.

322. THE NEW TESTAMENT.
(3-0) Cr. 3. W.S.
Prerequisite: 200.
The development of Christian thought and organization to the close of the New Testament period.

341. ANCIENT AND MEDIEVAL PHILOSOPHY.
(4-0) Cr. 4. F.
Prerequisite: 260.
An account of the rise of critical thought in early Greek and Christian schools of philosophy. Readings from Plato, Aristotle, the Stoics and Epicureans, Augustine, and Aquinas.

342. MODERN PHILOSOPHY.
(4-0) Cr. 4. W.
Prerequisite: 260.
The historical development of philosophical thought from the Renaissance through the eighteenth century. Readings from Bacon, Hobbes, Descartes, Spinoza, Leibniz, Locke, Berkeley, Hume, and Kant.

343. NINETEENTH CENTURY PHILOSOPHY.
(4-0) Cr. 4. S.
Prerequisite: 342.
Philosophical developments in the nineteenth century.

344. TWENTIETH CENTURY PHILOSOPHY.
(4-0) Cr. 4. F.
Prerequisite: 342.
Philosophical developments in the twentieth century: realism, pragmatism, positivism, existentialism, analytic philosophy.

351. RELIGIONS OF WESTERN ASIA.
(3-0) Cr. 3. F.
Prerequisite: 200 or 260.
Introduction to the ancient religions of Mesopotamia and the Mediterranean basin as background for understanding the historical development of Judaism, Zoroastrianism, and Islam.

352. RELIGIONS OF SOUTHERN AND SOUTHEASTERN ASIA.
(3-0) Cr. 3. W.
Prerequisite: 200 or 260.
Introduction to the basic religious patterns and teachings of Indian religions: Hinduism, Theravada Buddhism, Jainism, Sikhism.

353. RELIGIONS OF EAST ASIA.
(3-0) Cr. 3. S.
Prerequisite: 200 or 260.
Introduction to the religions of China, Korea, and Japan: Confucianism, Taoism, Shinto, and the schools of Mahayana Buddhism such as Amida and Zen.

357. PHILOSOPHY OF RELIGION.
(4-0) Cr. 4. F.S.
Prerequisite: 260.
Application of principles of philosophical method to basic issues of religious belief, emphasizing problems in religious knowledge, theistic claims, relation of religion and science, skeptical attacks upon religion. Illustrative material drawn from both Christianity and non-Christian world religions.

365. INTRODUCTION TO EXISTENTIALISM.
(4-0) Cr. 4. F.W.
Prerequisite: 260.
Systematic examination of the views of such men as Kierkegaard, Marcel, Heidegger, and Sartre.

370. SYMBOLIC LOGIC.
(3-0) Cr. 3. F.W.S.
Introduction to propositional and predicate calculi as well as intuitive set theory. Some applications to philosophy and the foundations of mathematics.

430. AESTHETICS.
(4-0) Cr. 4. S.
Prerequisite: 260.
An examination of some philosophical problems that arise in interpreting and evaluating the arts with particular attention to some representative theories of the nature of art, artistic creation, aesthetic experience, standards of taste, and criticism.

431. CONTEMPORARY ETHICAL THEORY.
(4-0) Cr. 4. W.
Prerequisite: 231.
Theoretical and normative issues in contemporary ethical thinking.

455. CHRISTIAN THOUGHT.
(3-0) Cr. 3. W.
Prerequisite: 200 or 260.
Historical development of Christian philosophy and theology; significant issues in the formulation of the creeds, the continental and English reformations, the Counter Reformation, the modern secularist attacks upon religion. Distinctive features of Roman Catholicism, Eastern Orthodoxy, Protestantism. Emphasis upon the interaction between Christian thought and secular, cultural and philosophic movements to show significance and influence of Christianity in the formation of Western culture and philosophy.

458. CONTEMPORARY CHRISTIAN THEOLOGY.
(3-0) Cr. 3. S.
Prerequisite: 200 or 260.
Selected theologians, and theological issues in contemporary Christianity, both Protestant and Roman Catholic.

460. CONTINENTAL RATIONALISM.
(4-0) Cr. 4. Alt. F, offered 1971.
Prerequisite: 342.
Critical exposition of seventeenth century rationalism as developed by Descartes, Spinoza, and Leibniz.

461. THE EMPIRICIST TRADITION.
(4-0) Cr. 4. Alt. F, offered 1972.
Prerequisite: 342.
Critical exposition of British empiricism as developed by Locke, Berkeley, and Hume.

462. SEMINAR IN EPISTEMOLOGY AND METAPHYSICS.
(4-0) Cr. 4. May be repeated for credit with permission of instructor. W.
Prerequisite: 344.
Issues in epistemology and metaphysics. Topics vary each time offered.

470. PHILOSOPHICAL ISSUES IN LOGIC.
(4-0) Cr. 4. F.
Prerequisite: 370.
Philosophical problems in logical theory and foundations of mathematics.

480, 481. PHILOSOPHY OF SCIENCE.
(4-0) Cr. 4 each. 480: F; 481: W.
Prerequisite: 480: 260 or 270; 481: 480.
Problems in philosophy of science: analysis of explanation, confirmation, meaning of scientific principles, metaphysical implications of scientific theories, justification of induction.

490. SPECIAL PROBLEMS.
Cr. 2 to 5 each time taken.
Prerequisite: Six credits in philosophy and permission of instructor. Approval of department head must be obtained prior to registration.
Guided reading and research on special topics selected to meet needs of advanced students.

PHYSICS

Clayton A. Swenson, Ph.D., Acting Chairman of Department

The Graduate Faculty

Members: J.E. Baglin, R.G. Barnes, G.H. Bowen, B.C. Carlson, J.R. Clem, B.C. Cook, G.C. Danielson, N.W. Dean, L.T. Earls, D.K. Finnemore, R. Fuchs, R.H. Good, C.L. Hammer, R.O. Haxby, E.N. Jensen, W.J. Kernan, D. Kirkham, K.L. Kliewer, R.C. Lamb, K.E. Lassila, R.A. Leacock, S. Legvold, S.H. Liu, D.W. Lynch, D.L. Pursey, K. Ruedenberg, S.K. Sinha, J.L. Stanford, C.A. Swenson, W.L. Talbert, Jr., T.A. Weber, S.A. Williams, B.L. Young, D.J. Zaffarano

Associate Members: W.I. Beavers, A.J. Bureau, B.S. Cooper, H.B. Crawley, A.S. Grossman, L. Hodges, R.C. Morrison, F.C. Peterson, J.I. Rhode, D.K. Ross, W.C. Schick, Jr., L.S. Schroeder, F.K. Wohn

The department offers work for the degrees Master of Science and Doctor of Philosophy with major in physics. Within this major the student may specialize in nuclear physics, solid state physics, high energy physics, or astrophysics at the Ph.D. level. Facilities of the department and of the Institute for Atomic Research, which are closely associated, permit theoretical and experimental investigations in these fields. Minor work is offered to students taking major work in other departments.

Students with bachelor's degrees in physics from other institutions ordinarily will qualify for graduate work here provided they have done satisfactory work in courses similar to those

suggested for undergraduate physics majors at this university. In some cases, additional training at the intermediate level may be required.

The Department of Physics requires all graduate students majoring in physics to teach as part of their training for an advanced degree.

Requirements for the degree of Master of Science in physics are as follows: at least 45 credits of acceptable graduate work must be completed, not less than 33 of which must be in physics, and not less than nine from other departments. At least 17 of the credits in physics must be in courses at the 500 or 600 level, exclusive of 595 and 699. Students choosing a degree with thesis may take up to 12 credits of 699, but no credits of 595 are to be applied toward the degree. Students choosing a degree without thesis should take one credit per quarter of 595 (Tutorial Physics), but may not apply research credits in 699 toward the degree. There is no foreign language requirement.

COURSES FOR GRADUATE STUDENTS, minor only

304. THERMODYNAMICS.
(3-0) Cr. 3. W.
Prerequisite: 223, Math. 213.
Concepts of temperature, entropy, and other characteristic thermodynamic functions; laws of thermodynamics and applications to macroscopic properties of matter.

310. UNDERGRADUATE ELECTRONICS LABORATORY.
(0-6) Cr. 3. F.
Prerequisite: Credit or classification in 394.
Basic properties of electronic components, amplifiers and pulse circuits, feedback.

311. UNDERGRADUATE LABORATORY.
(0-6) Cr. 3 each time taken. W.S.
Prerequisite: 233, Math. 213.
Experiments in classical and modern physics. Emphasis upon planning of experimental procedures.

344, 345, 346. INTRODUCTORY ASTROPHYSICS.
(3-0) Cr. 3 each. Yr.
Prerequisite: 223.
344: Astrophysical instruments, techniques, and fundamental data. The solar system. 345: Stellar structure. Spectral classification. Variable stars. Binary stars. 346: Interstellar matter. Star clusters. Galaxies, nebulae, and cosmology.

354, 355. INTERMEDIATE MECHANICS.
(3-0) Cr. 3 each. 354: W; 355: S.
Prerequisite: 223. Math. 213.
Newtonian mechanics; dynamics of particles, systems of particles, and rigid bodies. Lagrange's equations.

394. ELECTRONIC CIRCUITS.
(3-0) Cr. 3. F.
Prerequisite: 223, Math. 213.
Analysis of electronic circuits used in experimental physics. Steady state and transient analysis of passive and active networks with introduction to Laplace transform techniques as applied to circuits. Stability of electronic feedback systems.

411. SENIOR RESEARCH LABORATORY.
(0-6) Cr. 3 each time taken.
Prerequisite: Permission of instructor.
Projects in experimental or theoretical physics directed on a tutorial basis. Projects selected from fields of current research interest in physics. Emphasis on preparation of students for independent research.

421, 422, 423. INTERMEDIATE MODERN PHYSICS.
(3-0) Cr. 3 each. Yr.
Prerequisite: 223, Math. 322.
421: Special theory of relativity; four-vectors. Experimental foundations of the quantum theory of matter and radiation. (Primarily for students who have not taken 231, 232, 233.) 422: The Schroedinger equation and elementary applications to the structure of atoms, molecules, and solids. 423: Nuclear physics, including radioactive decay, the basic properties of nuclei, and nuclear reactions. Elementary particles and their interactions.

447, 448, 449. MODERN PHYSICS.
(3-0) Cr. 3 each. Yr.
Prerequisite: 223, Math. 322.
For students not majoring in physics. 447: Hamiltonian formulation of classical mechanics; Maxwell's equations; the Schroedinger equation. 448: Application of the Schroedinger equation to the hydrogen atom, the H_2^+ molecule ion, the helium atom, and electrons in a periodic lattice; semiclassical theory of absorption and emission of radiation. 449: Nuclear physics, relativistic energy, mass, momentum relations; nuclear masses and binding energies; alpha, beta, and gamma radioactivity; interaction of nuclear radiation with matter; nuclear reactions.

490. SPECIAL PROBLEMS.
Cr. 1 to 4 each time taken.
Prerequisite: Permission of instructor.
A. Acoustics.

494, 495. ELECTRICITY AND MAGNETISM.
(3-0) Cr. 3 each. 494: F; 495: W.
Prerequisite: 223, Math. 322, 410.
494: Electrostatics, magnetostatics, potential theory. 495: Maxwell's equations, dynamic fields, generation and propagation of electromagnetic waves in dielectric and conducting media.

496. OPTICS.
(3-0) Cr. 3. S.
Prerequisite: 495.
Dipole radiation, Fraunhofer diffraction; Kirchhoff integral, Fresnel diffraction, absorption, scattering and polarization, Zeeman effect, stimulated emission.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

501, 502. STELLAR INTERIORS.
(3-0) Cr. 3 each. 501: Alt. F, offered 1972; 502: Alt. W, offered 1973.
Prerequisite: 304, and 423 or 483.
501: Theory of the stellar interior. Polytropes and homology sequences. Stellar opacity and energy sources. Observational evidence of stellar evolution. White dwarfs. 502: Stellar models. Stellar evolution and nucleo-synthesis. Rotation and stellar stability. Cepheids, neutron stars.

504, 505. STELLAR ATMOSPHERES.
(3-0) Cr. 3 each. 504: Alt. F, offered 1971; 505: Alt. W, offered 1972.
Prerequisite: 304, and 423 or 483.
504: Radiative transfer. Model stellar atmospheres. 505: Spectral line formation and broadening mechanism. Curve of growth, abundances, departures from local thermodynamic equilibrium.

507. INTERSTELLAR MATTER.
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: 304, and 423 or 483.
Theory of physical processes in the interstellar medium: interstellar grains, galactic radio emissions, magnetic fields, and synchrotron radiation. Dilute radiation fields, gaseous nebulae, planetary nebulae, evolutionary role of interstellar matter.

510. OBSERVATIONAL ASTROPHYSICS.
(1-4) Cr. 3. F.SS.
Prerequisite: Permission of instructor.
Techniques of astrophysical data acquisition, reduction, and analysis, using photoelectric, spectrographic, and photographic equipment on a telescope.

511, 512, 513. SOLID STATE PHYSICS.
(3-0) Cr. 3 each. Yr.
Prerequisite: Credit or classification in 591, 592, 593 respectively.
Primarily for physics majors. Crystal symmetry, free electron model, band theory of solids, Fermi surface, transport properties, superconductivity, ferromagnetism.

517, 518, 519. SOLID STATE PHYSICS.
(3-0) Cr. 3 each. Yr.
Prerequisite: 303 or 423.
Primarily for students not majoring in physics. Topics are similar to 511, 512, 513, but with more emphasis on applications.

524, 525, 526. NUCLEAR PHYSICS.
(3-0) Cr. 3 each. Yr.
Prerequisite: 423 or 483.
Theory of nuclear reactions and alpha, beta, and gamma radioactivity; nuclei; nuclear models. Interaction of charged particles with matter.

531, 532. THERMODYNAMICS, STATISTICAL MECHANICS AND KINETIC THEORY.
(3-0) Cr. 3 each. 531: W; 532: S.
Prerequisite: 304, Math. 410.
The laws of thermodynamics; thermodynamic functions; applications to various systems; phase equilibria; principles of statistical mechanics; the microcanonical, canonical, and grand canonical ensembles of classical and quantum mechanics and their application to physical problems; kinetic theory and equation of state of gases; transport theory; Boltzmann transport equations; Brownian motion and noise.

534. EXPERIMENTAL TECHNIQUES IN HIGH ENERGY PHYSICS.
(3-0) Cr. 3. SS.
Prerequisite: Permission of instructor.
Bubble chamber techniques, design and use of beam transport systems, characteristics of present and planned accelerators, spark chamber, and counter techniques.

537, 538, 539. HIGH ENERGY PHYSICS.
(3-0) Cr. 3 each. Yr.
Prerequisite: Credit or classification in 591, 592, 593 respectively.
Special theory of relativity, reaction kinematics, basic properties of elementary particles and reactions, SU_3 and other classification schemes.

564. ADVANCED CLASSICAL MECHANICS.
(3-0) Cr. 3. F.
Prerequisite: 355 or 362; Math. 410.
Advanced methods and problems in dynamics. Lagrange and canonical equations, normal coordinates, rigid body mechanics, canonical transformation, Hamilton-Jacobi equations.

571, 572, 573. ADVANCED ELECTRICITY AND MAGNETISM.
(3-0) Cr. 3 each. Yr.
Prerequisite: Math. 322, 411.
571, 572: Electrostatics, magnetostatics, boundary value problems, Maxwell's equations, electromagnetic fields and wave phenomena in macroscopic media, wave guides. 573: Relativistic physics. Special theory of relativity, motion of charged particles, general theory of electromagnetic radiation, radiation produced by charges moving and in collision, radiation damping.

591, 592, 593. QUANTUM PHYSICS.
(3-0) Cr. 3 each. Yr.
Prerequisite: 355 and 423, or 483.
Schroedinger theory, representations, approximation methods, time-dependent problems, elementary scattering theory.

595. TUTORIAL PHYSICS.
Cr. var.
Prerequisite: Permission of instructor.

COURSES FOR GRADUATE STUDENTS, major or minor

611, 612, 613. QUANTUM THEORY OF SOLIDS.
(3-0) Cr. 3 each. Yr.
Prerequisite: 593.
611: X-ray and neutron diffraction; phonon dispersion relations; one-electron theory and band-structure calculations; exchange and correlation. 612: Optical properties; transport properties; conductivity; magnetic phenomena; the Fermi surface and its determination: cyclotron resonance, de Haas-van Alphen effect, ultrasonic attenuation, magnetoresistance. 613: Crystal field theory; magnetic resonance; cooperative phenomena; magnetism, superconductivity.

624, 625, 626. NUCLEAR THEORY.
(3-0) Cr. 3 each. Yr.
Prerequisite: 593.
624: Nuclear models and nuclear matter. 625: Beta decay and nuclear spectroscopy. 626: Nuclear reactions.

637, 638, 639. FUNDAMENTAL PARTICLE PHYSICS.
(3-0) Cr. 3 each. Yr.
Prerequisite: 593.
Relativistic quantum mechanics of particles with any spin. S-matrix theory. Applications of quantum electrodynamics. Regge poles. Current algebras. Applications in theory of weak and strong interactions.

650. ADVANCED SEMINAR.
(1-0) Cr. 1 each time taken. F.W.S.
Topics of current interest.
A. Nuclear Physics.
B. Solid State Physics.
C. Astrophysics.
D. High Energy Physics.

660. ADVANCED TOPICS IN PHYSICS.
Cr. 1 to 3 each time taken. F.W.S.
Courses on advanced topics and recent developments.
A. Nuclear Physics.
B. Solid State Physics.
C. Astrophysics.
D. High Energy Physics.

674, 675, 676. APPLICATION OF GROUP THEORY TO PHYSICS.
(3-0) Cr. 3 each. Alt. Yrs, offered 1972-1973.
Prerequisite: 593.
674: Theory of groups and group representations. Finite groups, with applications mainly to solid state physics and molecular theory. 675: Theory of continuous groups, with emphasis on the three-dimensional rotation group. The symmetric groups. Applications mainly to systems of many particles. 676: The symmetry properties of space-time. Unitary groups. Applications mainly to particle physics and to nuclear and atomic physics.

681, 682, 683. QUANTUM MECHANICS.
(3-0) Cr. 3 each. Yr.
Prerequisite: 593.
Angular momentum theory, second quantization, relativistic wave equations, symmetry operations, many-particle theory, propagators, S-matrix.

699. RESEARCH.

POLITICAL SCIENCE

Ross B. Talbot, Ph.D., Chairman of Department

The Graduate Faculty

Members: D.E. Boles, D.F. Hadwiger, W.R. Parks, R.B. Talbot, B.J. Teters, R.H.W. Theen, C.W. Wiggins

Associate Members: J.L. Hutter, V.A. Olorunsola, R.I. Wessel, F.L. Wilson

The department offers work for the degree Master of Arts with major in political science. The program is designed to enable its graduates to engage in governmental research, enter the public service or private industry, pursue further graduate study, or teach.

Prerequisite to major graduate work in the department is normally the completion of at least 21 credits in political science.

Each student entering the Master of Arts program in political science is expected to have completed one year of a foreign language (equivalent to 12 quarter credits) and a course in basic statistics (equivalent to Stat. 101). If he has not done so, the deficiency will have to be remedied by passing equivalent courses, for which no graduate credit will be received.

In addition, each student must complete *one* of the following requirements.

(1) Language—Two years of undergraduate instruction (including the one year of foreign language provided above) in a single language, with grades averaging 2.7 (on a 4.0 scale); or, a passing grade in the Educational Testing Service examination.

(2) Statistics—Successful completion of Stat. 401. Stat. 402 is recommended also, but not required. It is permissible to substitute Stat. 401 and 402 for Stat. 101 and 401, although to do so a student should audit 101 first.

These requirements are only the basic minimum. The student's advisory committee will decide if additional work, in either language or statistics, is necessary.

The department also offers a Master of Arts program, with no language requirement and a choice of a thesis or an internship requirement, to those students who wish to prepare for, or are employed in, government service.

COURSES FOR GRADUATE STUDENTS, minor only

410. IOWA GOVERNMENT AND POLITICS.
(3-0) Cr. 3. S.
Prerequisite: 215 or 310. Wiggins.
An analysis of Iowa government and politics, focusing upon major institutions of government: political parties, interest groups, legislature, supreme court, and chief executive. Role of municipalities and counties as local units of Iowa government.

420. CONSTITUTIONAL LAW.
(3-0) Cr. 3. F.
Prerequisite: 215. Boles.
Development of the United States Constitution through judicial action; influence of public law and judicial interpretations upon American government and society.

421. CIVIL LIBERTIES.
(3-0) Cr. 3. W.
Prerequisite: 215. Boles.
American constitutional and statutory guarantees of civil rights. First Amendment rights of conscience and freedom of expression as well as the rights of defendents. Application of equal protection of the laws to minority groups. Various reform proposals.

422. INTERNATIONAL LAW.
(3-0) Cr. 3. S.
Prerequisite: 215 or 251. Boles.
Development of the principles of international law of peace and war; analysis of theories concerning its nature and fundamental conceptions, its relation to national law; problems of international legislation and codification.

430. DEVELOPMENT OF POLITICAL THOUGHT: ANCIENT AND MEDIEVAL.
(3-0) Cr. 3. F.
Prerequisite: Six credits in political science or in European history. Shakeshaft.
Major political writings from Plato to Bodin. Primary emphasis on the study of translations of original works. An analysis of the ideas contained therein and of the relationships between the theories and their historical context.

431. DEVELOPMENT OF POLITICAL THOUGHT: 16th-18th CENTURIES.
(3-0) Cr. 3. W.
Prerequisite: Six credits in political science or in European history. Shakeshaft.
Major political philosophers from Bodin to Bentham.

432. DEVELOPMENT OF POLITICAL THOUGHT: 19th-20th CENTURIES.
(3-0) Cr. 3. S.
Prerequisite: 430 or 431. Shakeshaft.
Major political philosophers and schools of thought, beginning with Marx and J. S. Mill.

433. AMERICAN POLITICAL THOUGHT.
(3-0) Cr. 3. S.
Prerequisite: Six credits in political science or in American history. Talbot.
Analysis of major trends in the development of American political ideas, institutions, and theories.

434. POLITICAL SOCIALIZATION.
(3-0) Cr. 3. S.
Prerequisite: Six credits in political science, 330 recommended. Fitzpatrick.
Theories of civic education; political learning throughout life; political attitudes, cognitions, and values of preadults; agents of political socialization; the socialization process; systemic effects of political socialization.

440. BRITISH AND COMMONWEALTH GOVERNMENTS.
(3-0) Cr. 3. F.
Prerequisite: 241. Wilson.
The British political system and its influence on governments of the Commonwealth countries.

441. GOVERNMENTS OF WESTERN EUROPE.
(3-0) Cr. 3. W.
Prerequisite: 241. Wilson.
Comparative study of governments of France and Germany. Their governmental processes, political parties, electoral systems, and political problems. Comparison with United States.

442A. GOVERNMENTS OF CHINA AND JAPAN.
(3-0) Cr. 3. W.
Prerequisite: 241 or 3 credits from D.St. 207, 208, 209. Teters.
Political traditions and political cultures, contemporary governmental structures and processes.

442B. GOVERNMENTS OF INDIA, PAKISTAN, AND SOUTHEAST ASIA.
(3-0) Cr. 3. S.
Prerequisite: 241. Teters.
Political traditions and political cultures, contemporary governmental structures and processes.

443A. LATIN AMERICAN GOVERNMENTS.
(3-0) Cr. 3. W.
Prerequisite: 241 or 6 credits in Latin American history. Schmidt.
Political institutions and processes in the Latin American nations.

443B. RECENT LATIN AMERICAN POLITICS.
(3-0) Cr. 3. S.
Prerequisite: 241 or 6 credits in Latin American history. Schmidt.
Analysis of selected, current political problems in Latin America.

444. GOVERNMENT AND POLITICS OF THE SOVIET UNION.
(3-0) Cr. 3. F.
Prerequisite: 241 or 6 credits in Russian history. Theen.
Analysis of Russian political tradition. Organization and functioning of the Communist Party and its role in development of the Soviet Union. Governmental structure and processes of the Soviet political system.

445. POLITICS OF THE MIDDLE EAST.
(3-0) Cr. 3. Alt. S, offered 1973.
Prerequisite: 241 or 340.
Governments of the Middle East. Special attention to impact of social and technological change on the political process.

446A, 446B. GOVERNMENTS OF AFRICA: SOUTH OF THE SAHARA.
(3-0) Cr. 3 each. W.S.
Prerequisite: 241 or 3 credits from D.St. 204, 205, 206. Olorunsola.
Politics and governments of selected African states and territories south of the Sahara. 446A: West Africa. 446B: East Africa.

451. ASIA IN WORLD AFFAIRS.
(3-0) Cr. 3. S.
Prerequisite: 251 or D.St. 209. Teters.
Analysis of factors shaping objectives and politics of major Asian countries as participants in world politics.

452. COMPARATIVE FOREIGN POLICIES.
(3-0) Cr. 3. W.
Prerequisite: 251. Miller.
Foreign policies of selected nations other than the U.S.A. and U.S.S.R.

453. INTERNATIONAL ORGANIZATIONS.
(3-0) Cr. 3. S.
Prerequisite: 251. Miller.
Role of the United Nations and of regional organizations in the international system.

458. UNITED STATES FOREIGN POLICY.
(3-0) Cr. 3. W.S.
Prerequisite: 215, 251 recommended. Miller.
Elements of U.S. foreign policy, foreign policy-making process, governmental and nongovernmental agencies and forces operating on the formation of foreign policy, trends and issues, national purposes, diplomacy, and impact of the Cold War.

464. AMERICAN POLITICAL PARTIES.
(3-0) Cr. 3. F.
Prerequisite: Six credits in American government. Wiggins.
Systems theory applied to political parties, concepts of group structure, party evolution, party supporters and leaders, voting behavior, party in government.

467. INTEREST GROUPS IN AMERICAN POLITICS.
(3-0) Cr. 3. W.
Prerequisite: Six credits in American government. Hadwiger.
Historical development of political interest groups, major theories of their group roles, internal structure and operations of interest groups, relationship between interest groups and governing, including the role played by lobbyists in the political process.

468. PUBLIC OPINION AND PUBLIC POLICY.
(3-0) Cr. 3. S.
Prerequisite: Six credits in American government. Hadwiger.
Role of public opinion in American politics, dimensions and agencies of opinion formation, structure and distribution of opinions, opinion sampling of selected policy alternatives.

471. PUBLIC ADMINISTRATION.
(3-0) Cr. 3. F.
Prerequisite: Six credits in American government. Wessel.
Analysis of the operations of the executive branch of government. Problems of organizing that branch to achieve maximum efficiency.

472. GOVERNMENT AND REGULATION.
(3-0) Cr. 3. S.
Prerequisite: Six credits in American government. Wessel.
Structure and politics of regulatory agencies. Interactions of the executive, congress, judiciary, and regulatory agencies.

473. POLITICS OF FOOD AND FIBER POLICIES.
(3-0) Cr. 3. W.
Prerequisite: Six credits in American government. Youngberg.
The U.S. policy process as it relates to selected food and fiber policies: exports—commercial and concessional, imports, health and nutrition, welfare and education, research, price and income.

474. GOVERNMENT AND CONSERVATION POLICIES.
(3-0) Cr. 3. W.
Prerequisite: Six credits in American government. Talbot.
The political process in the area of public and private land, forest, water, and recreation policies. National legislative, executive, and administrative processes as they apply to federal grant-in-aid programs. State policies.

475. SCIENCE AND GOVERNMENT.
(3-0) Cr. 3. W.
Prerequisite: Six credits in American government. Talbot.
The political impact on selected policy development in certain Federal organizations, e.g., NASA, AEC, HEW, Commerce, and NSF.

476. ADMINISTRATIVE LAW.
(3-0) Cr. 3. S.
Prerequisite: 215. Boles.
Constitutional problems of delegation of governmental powers, elements of fair administrative procedures, judicial control over administrative determinations.

490. SPECIAL PROBLEMS.
Cr. 2 to 5 each time taken. F.W.S.
Special studies in the political institutions, processes and policies of American, foreign, and international governments. Also, studies in traditional and behavioral political theory.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

510. STATE GOVERNMENT AND POLITICS.
(3-0) Cr. 3. F.
Prerequisite: 310. Wiggins.
A comparative analysis of state political systems. Role of interest groups, political parties, legislatures, courts, and governors in state politics. Examination of possible determinants of public policy outputs at the state level.

511. PUBLIC POLICY AND LOCAL GOVERNMENT.
(3-0) Cr. 3. W.
Prerequisite: 310. Boles.
Analysis of structure, administration, and legal basis of the county, township, and special districts such as school and drainage districts. Evaluation of local governmental functions such as education, welfare, highways, including problems of taxation and finance. Effects of population shifts on future of local governments.

512. URBAN POLITICS.
(3-0) Cr. 3. W.
Prerequisite: 311. Fitzpatrick.
Structure and process of urban political systems, selected problems in urban politics.

520. PUBLIC LAW AND PUBLIC POLICY.
(3-0) Cr. 3. S.
Prerequisite: 320 or 420. Boles.
Role of the Federal judiciary in policy making in the United States. Jurisdictional limitations and judicial attitudes and personality in the decision-making process. Statistical analyses of judicial behavior.

530. ADVANCED POLITICAL THOUGHT.
(3-0) Cr. 3. S.
Prerequisite: Six credits in courses numbered 430 through 433. Shakeshaft.
Intensive study of one or more of the traditional and contemporary political philosophers.

531A. RESEARCH METHODS IN POLITICAL SCIENCE.
(3-0) Cr. 3. F.
Prerequisite: 331.
Survey research, questionnaire design, sampling, aggregate data collection and analysis, machine storage, and statistical analysis of data.

531B. RESEARCH METHODS IN POLITICAL SCIENCE.
(3-0) Cr. 3. W.
Prerequisite: 331.
Games, simulations, voting studies, legislative data, judicial data, scale construction, and other methods.

532A. BEHAVIORAL POLITICAL THEORY.
(3-0) Cr. 3. W.
Prerequisite: 330, 331. Hutter.
Systems theory, communications theory, structural-functional analysis, and other theories at the macro, or systemic, level.

532B. BEHAVIORAL POLITICAL THEORY.
(3-0) Cr. 3. S.
Prerequisite: 330, 331. Hutter.
Middle- or micro-level theory of empirical political behavior. Psychological, sociological, economic, and historical association with political behavior.

542. JAPANESE POLITICAL THOUGHT AND INSTITUTIONS.
(3-0) Cr. 3. Alt.S, offered 1972.
Prerequisite: 442A. Teters.
Japanese theories of the state and government. Development of Japanese political institutions. Particular attention to period since 1945.

544. RUSSIAN POLITICAL THOUGHT AND INSTITUTIONS.
(3-0) Cr. 3. S.
Prerequisite: 444 or 6 credits in Russian history. Theen.
Selected works in Russian political thought from the Decembrists to the present, especially those of Lenin. Development of Russian political thought since the Revolution and its relation to development of Russian political institutions.

556. SOVIET FOREIGN POLICY.
(3-0) Cr. 3. W.
Prerequisite: 444 or 6 credits in international studies and comparative politics. Theen.
Basic factors determining the formulation and execution of Soviet foreign policy. Analysis of the process and development of Russian foreign policy since 1917, emphasizing the Stalin period of the Cold War.

559. INTERNATIONAL RELATIONS THEORY.
(3-0) Cr. 3. F.
Prerequisite: Six credits in international studies. Miller.
A review, analysis, and application of recent theoretical attempts to order systematically the field of international relations. Special attention devoted to the concepts of power, equilibrium, communications, decision making, and systems analysis.

560. LEGISLATIVE BEHAVIOR.
(3-0) Cr. 3. S.
Prerequisite: Six credits in American government. Wiggins.
Principles, procedures, and problems of the legislative process. Structure and organization of state legislatures and the United States Congress.

561. THE CHIEF EXECUTIVE.
(3-0) Cr. 3. W.
Prerequisite: Nine credits in American government. Hadwiger.
Legal and political forces influencing the U.S. president, governors, and other governmental executives in decision making, developing and administering programs of government, leading public opinion, and influencing legislation.

563. CONTEMPORARY ISSUES IN AGRICULTURAL POLICY.
(Econ. 563) See Economics.

571. THE ADMINISTRATIVE PROCESS.
(5-0) Cr. 3. W.
Prerequisite: 471. Wessel.
An analysis of classic and current administrative theory, with applications to the budgetary process.

590. SPECIAL TOPICS.
Cr. 2 to 5 each time taken.
Prerequisite: Fifteen credits in political science, permission of instructor.
A. American Political Institutions.
B. Public Law.
C. Political Theory and Methodology.
D. Comparative Government.
E. International Relations.
F. Political Parties and Policy Formation.
G. Public Administration and Public Policy.

COURSES FOR GRADUATE STUDENTS, major or minor

610. GRADUATE SEMINARS.
(3-0) Cr. 3 for each seminar.
Prerequisite: Fifteen credits in graduate courses in political science.
A. American Political Institutions.
B. Public Law.
C. Political Theory and Methodology.
D. Comparative Government.
E. International Relations.
F. Policy Process.
G. Public Administration and Public Policy.

699. RESEARCH.

PSYCHOLOGY

Thomas W. Turnage, Ph.D., Head of Department

The Graduate Faculty

Members: L.R. Avant, W.H. Bartz, J.A. Bath, F.G. Brown, D.C. Charles, D.C. Edwards, M.F. Fritz, G.G. Karas, W.L. Layton, E.C. Lewis, D.H. Schuster, T.W. Turnage, J.A. Walsh, R. Warman, L. Wolins, D.G. Zytowski

Associate Members: C.R. Arnold, R.D. Baker, E.L. Betz, M.O. Bielefeld, E.S. Cherry, W.L. Davis, T.L. Dickinson, J.K. Dissinger, T.E. Hannum, L.L. Jacoby, A.S. Kahn, M.L. McManus, J.W. Menne, R.L. Patten, R.H. Peters, G.D. Phye, C.A. Poe, J.P. Wijting

The department offers work for the degrees Master of Science and Doctor of Philosophy with major in psychology, and minor work to students taking major work in other departments. A two-year Master of Science interdisciplinary program is offered in school psychology.

Students desiring a graduate major in psychology must have been graduated from an accredited college in a curriculum substantially equivalent to the undergraduate curriculum in Sciences and Humanities at Iowa State University. Prerequisite to admission is at least 15 credits of basic psychology, which should include a laboratory course and a measurement-statistics course.

There is no foreign language requirement for the advanced degrees offered by this department.

COURSES FOR GRADUATE STUDENTS, minor only

401. **HISTORY AND SYSTEMS IN PSYCHOLOGY.**
(3-0) Cr. 3. F.
Prerequisite: Twelve credits in psychology.
Philosophical and theoretical antecedents of contemporary psychology.

430. **PSYCHOLOGY OF ADOLESCENCE.**
(3-0) Cr. 3. F.W.S.SS.
Prerequisite: 230.
Developmental characteristics of the adolescent; examination of antecedents of behavior with a goal of better understanding of this age group; implications for education and guidance.

436. **PSYCHOLOGY OF EXCEPTIONAL CHILDREN.**
(3-0) Cr. 3. F.W.S.SS.
Prerequisite: 230, or C.D. 336 and 337.
Behavioral characteristics, problems, and needs of a wide variety of atypical children, including the gifted.

440. **PSYCHOLOGICAL MEASUREMENT I.**
(3-0) Cr. 3. F.W.S.SS.
Prerequisite: Six credits in psychology, Stat. 101.
Principles of psychological measurement including sources of test information, quantitative concepts with applications to test construction, factors influencing test performance, uses and misuses of tests in counseling, educational, and industrial settings.

441. **PSYCHOLOGICAL SCALING TECHNIQUES.**
(3-0) Cr. 3. S.
Prerequisite: 440.
Theory and techniques of psychological scaling, with emphasis on attitude scaling. Unidimensional approaches of Thurstone, Likert, Guttman. Introduction to multidimensional model.

451. **INDUSTRIAL PSYCHOLOGY I, II.**
(3-0) Cr. 3. W.S.
Prerequisite: 450.
Content and methods of industrial psychology with emphasis on industrial social psychology; employee motivation, morale, job satisfaction, leadership, communication, organization theory.

460. **PSYCHOLOGY OF ADJUSTMENT.**
(4-0) Cr. 4. F.W.S.SS.
Prerequisite: Nine credits in psychology.
Normal and abnormal modes of adjustment. Emphasis on motivation and learning in development of adjustment patterns.

490. **SPECIAL PROBLEMS.**
Cr. var.
Prerequisite: Six credits in psychology, permission of instructor.
Guided reading on special topics, or individual research projects. Permission of a faculty member must be obtained prior to registration.
A. History and Systems.
B. Safety.
C. Consumer.
D. Developmental.
E. Experimental.
F. Educational and Learning.
G. Individual Differences and Psychometrics.
I. Clinical and Abnormal.
J. Guidance, Personnel, Counseling.
K. Industrial-Organizational.
L. Exceptional Children.
M. School Psychology.
N. Social.

491. **SEMINAR IN PSYCHOLOGY.**
(1 to 3-0) Cr. 1 to 3 each time taken. Offered when demand warrants.
Prerequisite: Permission of instructor.
Seminars on special topics in psychology.

495. **APPLIED PSYCHOLOGY.**
(3-0) Cr. 3. W.
Prerequisite: 440, 9 additional credits in psychology.
Critical consideration of fields of applied psychology, including current research and applications in fields such as clinical, counseling, and industrial psychology.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

501, 502, 503, 504. **ADVANCED EXPERIMENTAL PSYCHOLOGY.**
(2-2) Cr. 3 each. 501, 502: F; 503: W; 504: S.
Prerequisite: Fifteen credits in psychology including 301 and 302 or the equivalent.
501: Advanced experimental investigation of sensory mechanisms and processes. 502: Perception and psychophysics. 503: Conditioning and animal studies of learning. 504: Human learning and concept formation. Laboratory research project required in each. Need not be taken in sequence.

505. **PSYCHOMETRICS.**
(Stat. 505) See Statistics.

506. **FACTOR ANALYSIS.**
(Stat. 506) See Statistics.

515, 516. ADVANCED PHYSIOLOGICAL PSYCHOLOGY.
(3-0) Cr. 3 each. 515: Alt.S, offered 1972; 516: Alt.S, offered 1973.
Prerequisite: Zool. 320 and 455, or V. Anat. 217 and V.Pharm. 264.
515: Neurophysiological correlates of behavior with emphasis on sensory-motor systems. 516: Neurophysiological correlates of behavior with emphasis on motivation and learning.

522. PSYCHOLOGY OF COUNSELING.
(3-0) Cr. 3. F.S.
Prerequisite: 440 and 12 additional credits in psychology.
Counseling procedures and techniques. Theory, research, and evaluation of counseling. Counseling as a profession.

523. VOCATIONAL PSYCHOLOGY.
(2-2) Cr. 3. W.
Prerequisite: Nine credits in psychology.
Theories of vocational behavior, including vocational choice, and their relationship to job satisfaction and job performance. Developmental aspects and occupational classification systems.

530. ADVANCED DEVELOPMENTAL PSYCHOLOGY.
(3-0) Cr. 3. S.SS.
Prerequisite: 230 or C.D. 336, 9 additional credits in psychology.
Critical evaluation of major research in physical, sensory, intellectual, emotional, and social development. Human behavior from conception to senescence. Maturity and old age emphasized.

531. PSYCHOLOGY OF EXCEPTIONAL INTELLIGENCE.
(3-0) Cr. 3. Alt. F, offered 1971.
Prerequisite: 436, 12 additional credits in psychology.
Study of psychological characteristics of the mentally deficient, and the gifted and creative. Theoretical views, current research in learning and cognition, perception, language, motor skills, adjustment; implications for clinical and educational practice.

533. ADVANCED EDUCATIONAL PSYCHOLOGY.
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: 333, 6 additional credits in psychology.
Examination of learning theories as they relate to educational practices. Review and evaluation of research findings involving applications of learning principles to educational practices.

534. RESEARCH METHODS IN EDUCATIONAL PSYCHOLOGY.
(3-0) Cr. 3. Alt. S, offered 1973. SS.
Prerequisite: 333, 6 additional credits in psychology.
Application of psychological principles and methodology to study of educational problems. Consideration of education as a behavioral science. Design and evaluation of psychological research on problems related to education.

535. PSYCHOLOGY OF READING.
(3-0) Cr. 3. Alt. W, offered 1973.
Prerequisite: 230, 333.
Psychology of the reading process, its nature and development including effects of both internal and external factors on performance. Evaluation and diagnosis of reading skills. Remedial and developmental procedures.

540. PSYCHOLOGICAL MEASUREMENT II.
(3-0) Cr. 3. W.
Prerequisite: 440, Stat. 401.
Theoretical and instrumental definition of variables. Theoretical and philosophical approaches to reliability and validity.

541. INDIVIDUAL MENTAL TESTING: ADULTS.
(2-3) Cr. 3. Alt. S, offered 1972.
Prerequisite: 440, permission of instructor.
Theory of individual mental testing. Development of commonly used tests at the adult level. Techniques of administering, scoring, and interpreting the results of individually administered mental tests at the adult level. Practicum included.

542. INDIVIDUAL MENTAL TESTING: CHILDREN.
(2-3) Cr. 3. W.SS.
Prerequisite: 440, permission of instructor.
Theory of individual mental testing. Development of commonly used tests for children. Techniques of administering, scoring, and interpreting the results of individually administered tests for children. Practicum included.

545. DIFFERENTIAL PSYCHOLOGY.
(3-0) Cr. 3. S.
Prerequisite: 440.
Individual differences in behavior and their determinants. Trait definitions. Genetics of behavior. Interaction of heredity and environment. Research methods.

550. PERFORMANCE MEASUREMENT.
(3-0) Cr. 3. Alt. F, offered 1972.
Prerequisite: 440 or permission of instructor.
Development of dependent variables in applied behavioral research. Measurement of performance effectiveness. Applications in industry, education, other applied psychological settings.

551. ORGANIZATIONAL PSYCHOLOGY.
(3-0) Cr. 3. Alt. W, offered 1973.
Prerequisite: 451, 550.
Methods, theory, and practice of industrial-social psychology, with emphasis on behavioral research in industrial settings.

560. PERSONALITY THEORIES.
(3-0) Cr. 3. F.
Prerequisite: 460 or graduate standing.
Major concepts, methods, and problems in study of personality. Analysis of theories of personality, with emphasis on personality development in the normal population.

561. PSYCHOPATHOLOGY AND BEHAVIOR DEVIATIONS.
(3-0) Cr. 3. W.
Prerequisite: 460 or graduate standing.
Application of personality theory to the study of abnormal behavior. Analysis of etiology and dynamics of various psychopathological entities, including psychoneuroses and psychoses.

562. PERSONALITY ASSESSMENT.
(3-0) Cr. 3. S.
Prerequisite: 460 or graduate standing.
Basic concepts underlying personality assessment. Objective and projective methods for measurement of personality.

580. ADVANCED SOCIAL PSYCHOLOGY I.
(3-0) Cr. 3. F.SS.
Prerequisite: 380, 9 additional credits in psychology.
Research methods and contemporary theories in social psychology, emphasizing attitude formation and change, perception of other people, attraction, and aggression.

581. ADVANCED SOCIAL PSYCHOLOGY II.
(3-0) Cr. 3. W.
Prerequisite: 380, 9 additional credits in psychology.
Theoretical and empirical study of the effects of group membership on individual behavior.

590. SPECIAL TOPICS.
Cr. var.
Prerequisite: Twelve credits in psychology, permission of instructor.
Guided reading on special topics, or individual research projects. Permission of a faculty member must be obtained prior to registration.
A. History and Systems.
B. Safety.
C. Consumer.
D. Developmental.
E. Experimental.
F. Educational and Learning.
G. Individual Differences and Psychometrics.
I. Clinical and Abnormal.
J. Guidance, Personnel, Counseling.
K. Industrial-Organizational.
L. Exceptional Children.
M. School Psychology.
N. Social.

COURSES FOR GRADUATE STUDENTS, major or minor

601, 602, 603. HISTORICAL AND SYSTEMATIC PSYCHOLOGY.
(2-0) Cr. 2 each. Yr.
Prerequisite: 601: Second year graduate standing; 602: 601; 603: 602.
601: Origins of psychology in classical, medieval, and Renaissance thought. Development of psychology as a science in nineteenth and twentieth centuries. Historical roots of contemporary problems. 602: Philosophical and methodological problems of psychology. Traditional and contemporary procedures and strategies in the study of psychology. 603: Traditional and contemporary theoretical approaches to learning, sensation-perception, personality, development, and abnormal psychology.

604. COGNITION.
(3-0) Cr. 3. F.
Prerequisite: 504.
Advanced experimental investigation and theory of cognitive processes including thinking, problem-solving, and conceptual behavior.

605. PSYCHOLOGY OF MOTIVATION.
(2-0) Cr. 2. W.
Prerequisite: 503 or 504.
Major research findings and theoretical concepts in the psychology of motivation.

607. ETHOLOGY.
(Zool. 607) See Zoology.

620. PSYCHOLOGICAL COUNSELING.
(3-0) Cr. 3. F.W.S.
Prerequisite: 522.
Advanced theory and practice in psychological counseling with emphasis on application of counseling and testing techniques. Case studies and role playing.

633. TEACHING OF PSYCHOLOGY.
(3-0) Cr. 3. F.S.
Prerequisite: Enrollment in Ph.D. or terminal M.S. program in psychology, completion of at least one year graduate study, permission of instructor.
Orientation to teaching of psychology at college level: academic issues and problems, instructional and evaluative techniques.

691. PRACTICUM IN PSYCHOLOGY.
Cr. var.
Prerequisite: Permission of instructor.
Supervised practice and experience in the following fields of specialization in applied psychology.
A. Counseling Psychology.
B. Industrial Psychology.
C. School Psychology.
D. Individual Testing.
E. Teaching of Psychology.

692. SEMINAR IN PSYCHOLOGY.
(1 to 3-0) Cr. 1 to 3 each time taken. Offered when demand warrants.
Prerequisite: Graduate standing.
A. Counseling.
B. Educational-Developmental.
C. General-Experimental.
D. Industrial-Organizational.
E. Psychometrics.
F. School Psychology.

699. RESEARCH.

SOCIOLOGY AND ANTHROPOLOGY

George M. Beal, Ph.D., Chairman of Department

The Graduate Faculty

Members: G.M. Beal, J.M. Bohlen, G.L. Bultena, D.G. Dean, G.E. Klonglan, C.L. Mulford, R.C. Powers, M.C. Warning, R.D. Warren

Associate Members: B.C. Agrawal, H.C. Chang, H. Cohen, D.M. Gradwohl, P. Keith, E.A. Powers, R.O. Richards, D.L. Rogers, L.D. Wilcox, J.P. Yarbrough, D.R. Yoesting

The department offers work for the degrees Master of Science and Doctor of Philosophy with majors in sociology and rural sociology and minor work for students majoring in other departments. Within the major of sociology, students may specialize in family, complex organization, population, research methods, community, social change, theory, and leisure and environmental resources. Within the sociology major students may specialize in anthropology at the master's level.

The department stipulates no language requirement for either the degree Master of Sci-

ence or the degree Doctor of Philosophy. However, it may be relevant in individual cases to specify competence in one or more languages.

The department is a cooperating department in the industrial relations program. (See *Industrial Relations.)*

SOCIOLOGY

COURSES FOR GRADUATE STUDENTS, minor only

400. HISTORY OF SOCIOLOGICAL THOUGHT.
(3-0) Cr. 3. W.
Prerequisite: Nine credits in sociology.
Origin and development of sociological thought from earliest times to 1860.

401. CONTEMPORARY SOCIOLOGICAL THEORIES.
(3-0) Cr. 3. W.S.SSII.
Prerequisite: Twelve credits in sociology.
Analysis of major theories from 1860 to present.

410. URBAN SOCIOLOGY.
(3-0) Cr. 3. F.W.S.SS.
Prerequisite: 130 or 134.
Growth, structure, and functions of the city; urban-social relations.

440. SYSTEMS ANALYSIS OF CRIMINAL AND JUVENILE JUSTICE.
(3-0) Cr. 3. W.
Prerequisite: 340.
Criminal and juvenile justice: detection, labeling and arrest, prosecution, adjudication, sentencing, imprisonment, release, revocation.

445. DEMOGRAPHIC ANALYSIS.
(3-0) Cr. 3. F.S., SSI 1972, SSII 1973.
Prerequisite: 130 or 134.
Dynamics of population development with emphasis on theories of population; fertility, mortality, and migration as components of population change; techniques of measurement of demographic phenomena; projection of population trends.

450. HUMAN ECOLOGY.
(3-0) Cr. 3. F.W., SSI. 1973, SSII. 1972.
Prerequisite: 130 or 134.
Development of human ecology as a discipline and its relationship to general ecology; basic concepts, theories, and methods developed by human ecologists as applied to the study of cities, community structure, social areas, and sociocultural elements as determinants of man's relationship to environment; the ecosystem as a frame of reference.

454. FIELD OBSERVATION AND PRACTICE.
Cr. 1 to 3 each time taken. F.W.S.SS.
Prerequisite: Nine credits in sociology.
Supervised practice in established organizations and agencies.
A. Rural Organizations and Group Work Agencies.
B. Industrial Plants and Related Organizations.
D. Family Life Education and Agencies.

461. INTRODUCTION TO SOCIAL WELFARE.
(3-0) Cr. 3. F.
Prerequisite: Nine credits in sociology.
Policy issues, comparative institutional materials (historical and cross-cultural), normative and organizational structure.

462. INTRODUCTION TO SOCIAL WORK.
(3-0) Cr. 3. W.
Prerequisite: 461.
Current theories and practices in social case work, group work, and community organization.

464. COMMUNITY ACTION.
(3-0) Cr. 3. F.W.S.SSI.
Prerequisite: 202.
Community analysis of mobilization and organization of human and social system resources for social action programs.

471. SOCIOLOGY OF EDUCATION.
(3-0) Cr. 3. F.W.S.SS.
Prerequisite: 130 or 134; Educ. 204 for education majors.
American schools as social organizations, as community institutions, and as socialization agents.

473. SOCIOLOGY OF YOUTH.
(3-0) Cr. 3. W.S.SSII.
Prerequisite: 130 or 134.
Social analysis of the development of self, integration into adult society, effect of peer and sibling relationships, the social implications of youth transitions into adult culture.

480. INDUSTRIAL SOCIOLOGY.
(3-0) Cr. 3. F.
Prerequisite: 380.
Implications of technological change on modern industrial organizations.

482. SOCIAL BEHAVIOR AND ENVIRONMENTAL RESOURCES.
(3-0) Cr. 3. F.S.SSII.
Prerequisite: 130 or 134; Biol. 103 recommended.
Natural resource problems, value orientations toward the environment, environmental quality and quantity as social problems, conservation as a social movement, organizational patterns in resources management.

483. SOCIOLOGY OF LEISURE AND RECREATION.
(3-0) Cr. 3. W.S.SSI.
Prerequisite: 130 or 134.
The social significance of leisure, the human values in leisure-time pursuits, evaluation of current uses of leisure, the social institutional structure and functional systems of society related to leisure behavior.

485. SOCIOLOGY OF THE FAMILY.
(3-0) Cr. 3. F.W.S.SS.
Prerequisite: 130 or 134.
Analysis of the family as a group; cultural influences, group processes, and institutional aspects.

486. LEADERSHIP AND SOCIAL INTERACTION.
(3-0) Cr. 3. W.S.SS.
Prerequisite: 130 or 134.
Genesis of leadership, leader-follower roles and leader types in modern society, case studies of contemporary theories. A sociological analysis of community leadership. Review of findings relative to formal and informal leadership patterns in the community organizations. Implications of leadership patterns for community action.

490. SPECIAL PROBLEMS.
Cr. 1 to 5 each time taken.
Prerequisite: Nine credits in sociology.
A. General Sociology.
B. Rural Sociology.
C. Social Problems.
D. Industrial Sociology.
E. Family Sociology.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

501, 502. INTERMEDIATE THEORETICAL ANALYSIS.
(3-0) Cr. 3 each. 501: W; 502: S.
Prerequisite: 503.
501: Contemporary theories in micro-sociology with emphasis on symbolic interactionism. 502: Contemporary theories of macro-sociology with emphasis on social change in communities, societies, and general social systems.

503. INTERMEDIATE SOCIOLOGICAL INQUIRY AND THEORY.
(3-0) Cr. 3. F.
Prerequisite: 401.
Science and sociology. Units of sociological analysis. Taxonomies in sociology; concepts, subconcepts, levels of concepts. Elements of systematic sociological theory; propositions, explanation, prediction, cause. Use of sociological theory in research.

504. SOCIAL ORGANIZATION.
(3-0) Cr. 3. S.
Prerequisite: 503.
Theories of social organization, group structure and process as frames of reference. Differentiating factors affecting the structure of society, classification of basic social forms.

505. PRIMARY RELATIONS.
(3-0) Cr. 3. Alt. W, offered 1972.
Prerequisite: 305 or Psych. 380.
Analytic treatment of diffuse, affective interpersonal relations; development of such primary relations in a variety of social situations; importance of primary relations in identity development and maintenance of social organizations.

511. INTERMEDIATE RESEARCH METHODS IN SOCIOLOGY.
(3-0) Cr. 3. F.
Prerequisite: 302.
Kinds of inferences to be made from survey data and experimental data. Evaluation of current literature.

570. SOCIAL ORDER AND SOCIAL CONFLICT.
(3-0) Cr. 3. Alt. F, offered 1972.
Prerequisite Nine credits in sociology.
Sociological analysis of power, power structure, mass society, and elite formation; conflict management.

585. SOCIAL CHANGE AND THE FAMILY.
(3-0) Cr. 3. F.
Prerequisite: 485.
Analysis of the interrelationships of the family institution and social change; industrialization, urbanization, modernization, mobility. Functions of the family in a modern and changing society.

590. SPECIAL TOPICS.
Cr. 1 to 5 each time taken.
Prerequisite: Fifteen credits in sociology.
A. General Sociology.
C. Social Problems.
D. Industrial Sociology.
E. Family Sociology.
F. Leisure and Environmental Resources.
R. Rural Sociology.

COURSES FOR GRADUATE STUDENTS, major or minor

600, 601. ADVANCED THEORETICAL ANALYSIS.
(3-0) Cr. 3. 600: W; 601: S.
Prerequisite: 503.
600: Contemporary theory construction in sociology, concept formation, models in sociology, stages in the development of sociological theory. Formal strategies to theory construction. 601: Philosophical and theoretical bases of sociology. Historical antecedents of contemporary sociological theories. Comparison of various schools in sociology.

611. SOCIOLOGICAL MEASUREMENT.
(3-0) Cr. 3. Alt. W, offered 1972.
Prerequisite: 503, 511.
Principles of measurement of major sociological variables. Foundations of measurement; types of sociological variables; construction of sociological measures, indices, and scales; methods of data collection.

613. CAUSAL MODELS IN SOCIOLOGY.
(3-0) Cr. 3. Alt. S, offered 1973.
Prerequisite: 503, Stat. 401.
The notion of causality in sociology, cause in social theory and in social method, contemporary approaches to causal analysis.

692. SOCIOLOGY OF ADOPTION AND DIFFUSION.
(3-0) Cr. 3. Alt. F, offered 1971.
Prerequisite: 501, and 502 or 504.
Sociological aspects of adoption and diffusion of new ideas and technology. Discussion of adoption models and factors related to rates and intensity of adoption and diffusion. Adoption unit characteristics related to rates of adoption.

698. SEMINARS IN SOCIOLOGY.
(3-0) Cr. 3 each.
A. Social Theory. F.SSI.
B. Social Organization. W.
C. Population. W. Alt. SSII, offered 1973.
D. Social Interaction and Communication. Alt. F, offered 1971.
E. Social Disorganization. F.
F. Social Change. Alt. W, offered 1973, Alt. SSI, offered 1972.
G. Human Ecology. Alt. S, offered 1973, SSII, offered 1972.
H. Research Methods. F.W.S.
J. Industrial Sociology. Alt. W, offered 1972.
L. Current Emphases in Marriage and the Family. S, Alt. SSI, offered 1972.
M. Research in Marriage and Family. W, Alt. SSII, offered 1973.
N. Community. F.
O. Bureaucracy. Alt. W, offered 1972.
P. Current Research. F.W.S.SS.
S. Small Group Theory and Research. Alt.S, offered 1972.
T. Role Theory. Alt. S, offered 1973.
U. Sociology of Knowledge. Alt. W, offered 1972.
V. Leisure and Environmental Resources. SSI.
W. Sociology of Education. S.SSI.

699. RESEARCH.
A. Rural Sociology.
B. General Sociology.

ANTHROPOLOGY

COURSES FOR GRADUATE STUDENTS, minor only

400. **LANGUAGE AND CULTURE.**
(3-0) Cr. 3. Alt. W, offered 1972.
Prerequisite: 218.
Structure and design of language; language and cognition; semantics; linguistic change; social and linguistic aspects of verbal behavior; language, world view, and cognitive style.

420. **ARCHAEOLOGY OF NORTH AMERICA.**
(3-0) Cr. 3. S.
Prerequisite: 220 or 322.
Prehistory and early history of North America as reconstructed from archaeological evidence, peopling of the New World, major culture historical developments north of the Rio Grande.

421. **KINSHIP IN DIFFERENT CULTURES.**
(3-0) Cr. 3. S.
Prerequisite: 218 or 313.
Kinship theory, comparative analysis of kinship systems, structure and functions of kinship relations in various cultures.

422. **CULTURE AND PERSONALITY.**
(3-0) Cr. 3. W.
Prerequisite: 218, Psych. 101.
Relationship of cultural, social, and personality factors in human behavior; analysis of generational transmission of culure.

424. **ETHNOLOGY OF THE OLD WORLD.**
(3-0) Cr. 3. W.
Prerequisite: 218.
Selected old world cultures: Africa, Europe, Asia, or Oceania.

425. **CULTURE CHANGE.**
(3-0) Cr. 3. F.
Prerequisite: 218.
Culture contact and change, impact of Western peoples and civilization on economically undeveloped areas.

426. **ARCHAEOLOGY OF EUROPE AND THE NEAR EAST.**
(3-0) Cr. 3. Alt. W, offered 1973.
Prerequisite: 220.
Prehistoric and early literate cultures of Europe as reconstructed from archaeological evidence, prehistoric background of Near Eastern and Mediterranean civilizations.

428. **ARCHAEOLOGICAL LABORATORY METHODS AND TECHNIQUES.**
Cr. 1 to 5. F.W.S.
Prerequisite: Three credits in anthropology, permission of instructor.
Laboratory processing and analysis of archaeological materials, preparation of preliminary archaeological report.

429. **ARCHAEOLOGICAL FIELD SCHOOL.**
Cr. 8 to 12. SS. 8-10 weeks.
Prerequisite: Three credits in anthropology, permission of instructor.
Summer field school for training in archaeological reconnaissance and excavation techniques; documentation and interpretation of archaeological evidence.

430. **ETHNOLOGICAL FIELD METHODS.**
(3-0) Cr. 3. Alt. F, offered 1971.
Prerequisite: 218, six additional credits of anthropology or sociology or combination.
Concepts and strategy of anthropological field work, participant observation, theory and method in collection and analysis of ethnographic information.

490. **SPECIAL PROBLEMS.**
Cr. 1 to 5 each time taken.
Prerequisite: Nine credits in anthropology.
A. Archaeology.
B. Cultural Anthropology.
C. Physical Anthropology.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

510. **SOCIAL ANTHROPOLOGY.**
(4-0) Cr. 4. S.
Prerequisite: 218; 340 or 421; 322 or 424.
Historical development of social anthropology, systematic survey of the structuralist-functionalist approach, special analysis of social structure and social organization.

520. **CULTURAL CONTINUITY AND CHANGE IN THE PRAIRIE-PLAINS.**
(3-0) Cr. 3. Alt. W, offered 1972.
Prerequisite: 322 or 420 or 429; 425.
Ecological adaptations and sociocultural change among Prairie and Plains Indian groups through time.

529. **ADVANCED ARCHAEOLOGICAL METHODS.**
Cr. 1 to 5. F.W.S. May be taken for 8 to 12 credits in summer field school.
Prerequisite: 429, permission of instructor.
Archaeological field techniques and laboratory methods. Reconstruction of sociocultural activities from archaeological evidence.

530. **FIELD PROBLEMS IN THE ETHNOGRAPHY OF CONTEMPORARY SOCIETIES.**
Cr. 1 to 5. F.W.S. May be taken for 8 to 12 credits in summer field school.
Prerequisite: 430, permission of instructor.
Field training experience in ethnography, problems emphasizing field studies in the contemporary societies of the world.

550. **HISTORY AND DEVELOPMENT OF ANTHROPOLOGICAL THEORY.**
(3-0) Cr. 3. Alt. F, offered 1972.
Prerequisite: Nine credits in anthropology, permission of instructor.
Historical development of anthropological theories and concepts; systematic survey of major theoretical areas of social and cultural anthropology; nature of anthropology as a discipline.

590. **SPECIAL TOPICS.**
Cr. 1 to 5.
Prerequisite: Fifteen credits in anthropology.
A. Archaeology of New World.
B. Archaeology of Old World.
C. Biological Anthropology of New World.
D. Biological Anthropology of Old World.
E. Cultural-Social Anthropology of New World.
F. Cultural-Social Anthropology of Old World.
G. Linguistic and Cognitive Anthropology of New World.
H. Linguistic and Cognitive Anthropology of Old World.

COURSES FOR GRADUATE STUDENTS, major or minor

698. ADVANCED TOPICS IN ANTHROPOLOGY.
(3-0) Cr. 3 each.
A. General Anthropology.
B. Archaeology.
C. Cultural Ecology.
D. Applied Anthropology.
E. Economic Anthropology.
F. Psychological Anthropology.
G. Political Anthropology.
H. Urban Anthropology.
I. Magico-Religious Systems.
J. Kinship Studies.

699. RESEARCH.

SPEECH

William R. Underhill, Ph.D., Chairman of Department

COURSES FOR GRADUATE STUDENTS, minor only

327. PERSUASION.
(3-0) Cr. 3. F.W.S.
Prerequisite: 211.
Examination of behavioral research in persuasion; scientific methods of evaluating persuasive communication; emphasis on application of experimental research.

329. PERSUASIVE SPEAKING.
(3-0) Cr. 3. S.
Prerequisite: 327.
Audience analysis, attention, perception, suggestion, logical and emotional proof; ethics of a persuasive speaker; use of videotape for analysis.

400A, 400B, 400C. TELECOMMUNICATIVE ARTS.
(Jl. 400C) (1-3 to 9) Cr. 1 to 3 each time taken. 400A: Maximum of 6 credits; 400B: Maximum of 10 credits; 400C: Maximum of 8 credits. 400A, 400C; F.W.S; 400B: F.W.S.SSI.
Prerequisite: 400A: 331, 332, 348, permission of instructor. 400B: 332, 432, permission of instructor. 400C: 319, 400B, permission of instructor.
400A: Creating, writing, and directing of a variety of educational and public information programs. Research methods, narrative and expositional writing techniques, audio control, direction of talent, production procedures. Selected programs each week on WOI-FM-AM. 400B: Television. Students who previously have emphasized writing, lighting, staging, newscasting, demonstration, and performing will work as crews to create, write, direct, and produce programs for weekly broadcasts on WOI-TV. 400C: The first of a four-quarter sequence starts in the spring, and is offered as a lecture and discussion course in production procedures. Advanced students write, direct, and produce dramatic and informational sound motion pictures during the following three quarters.

431. TELEVISION PRODUCTION.
(3-0) Cr. 3. F.
Prerequisite: 234, 337.
Theory and practice of television production. Programs analyzed with reference to staging, lighting, sound, shooting, and switching.

432. TELEVISION DIRECTION.
(1-4) Cr. 3. W.
Prerequisite: 431.
Translation of facts, ideas, emotions, and attitudes into meaningful visual and aural images.

465. HISTORY OF THEATRE.
(3-0) Cr. 3. F.
Prerequisite: 106.
Theatrical art from ancient times through the Middle Ages.

478. LANGUAGE DISORDERS OF CHILDREN.
(3-0) Cr. 3. W.
Prerequisite: 375.
Normal language development, bases and diagnosis of language disorders in children, methodologies for habilitating children with language disturbances.

510. CLASSICAL RHETORIC.
(4-0) Cr. 4. W.
Prerequisite: 412.
Greek and Roman tradition in rhetorical theory, practice, criticism, and pedagogy.

516. AMERICAN PUBLIC ADDRESS.
(3-0) Cr. 3. W.
Prerequisite: Twelve credits in speech including 412.
Relations between speakers, speeches, and political or historical events.

556. DIRECTING THE EDUCATIONAL THEATRE PROGRAM.
(3-0) Cr. 3. SSI.
Prerequisite: Graduate standing, permission of instructor.
Problems in directing educational theatre, play selection and new dramatic literature, theatre management, directing college and high school drama programs, conducting high school drama contests and festivals.

590. SPECIAL TOPICS.
Cr. 2 to 6 each time taken, maximum of 18 credits.
Prerequisite: Permission of department chairman.
A. Rhetoric and Public Address.
B. Speech Correction.
C. Theatre.
D. Speech Education.
E. Radio, Television, and Film.

STATISTICS

Theodore A. Bancroft, Ph.D., Head of Department

The Graduate Faculty

Members: B.C. Arnold, T.A. Bancroft, C.P. Cox, D.F. Cox, H.T. David, W.A. Fuller, C.P. Han, O. Kempthorne, E. Pollak, J.K. Sengupta, B.V. Sukhatme, J.A. Walsh, R.D. Warren, L. Wolins, G. Zyskind

Associate Members: J. Geadelmann, R.A. Groenveld, R. Hickman, P.N. Hinz, D.J. Hotchkiss, D.V. Huntsberger, D.L. Isaacson, W.J. Kennedy, G.D. Meeden, R.W. Mensing, V.A. Sposito, N.V. Strand, S.B. Sukhatme

The department offers work for the degrees Master of Science and Doctor of Philosophy with major in statistics, and minor work to students taking major work in other departments.

Prerequisite to major graduate work is the completion of an undergraduate curriculum essentially equivalent to the curriculum in Sciences and Humanities at this institution, together with a year of calculus and a knowledge of statistical theory and methods as contained in Stat. 341, 342, 343, 401, 402.

The degree Master of Science may be earned on either a thesis or nonthesis basis. The nonthesis option requires the completion of at least 51 credits of acceptable graduate work and satisfactory performance on a written examination.

There is no uniform language requirement for graduate students majoring in statistics. The department encourages the student to prepare himself in foreign languages and in computer language, but specific requirements for the degrees Master of Science and Doctor of Philosophy are at the discretion of the student's advisory committee.

COURSES FOR GRADUATE STUDENTS, minor only

401, 402. STATISTICAL METHODS FOR RESEARCH WORKERS.
(3-3) Cr. 4 each. 401: F.W.SSI; 402: W.S.SSII.
Prerequisite: 401: 101 or graduate classification, 5 credits in mathematics; 402: 401.
The role of statistics in research. Introduction to the methods of analyzing data from experiments and surveys. 401: Statistical concepts and models; estimation; simple tests of significance; linear regression and correlation; introduction to analysis of variance. 402: Methods of analysis of variance including cross classifications; introduction to multiple comparisons; factorials; individual degrees of freedom; multiple regression; covariance.

403. NONPARAMETRIC STATISTICAL METHODS.
(3-0) Cr. 3. Alt. F, offered 1972.
Prerequisite: 401.
Analytical procedures for statistical data when the dependent variable has ordinal or nominal properties; elaborations of chi-square procedures; randomization procedures for ranked data and data having interval properties; efficiency of nonparametric procedures and robustness of comparable parametric procedures.

411. EXPERIMENTAL DESIGN FOR RESEARCH WORKERS.
(3-0) Cr. 3. S.SSI.
Prerequisite: 402.
Methods of constructing and analyzing designs for experimental investigations; concepts of blocking, randomization, and replication; experimental unit technique; complete block designs; confounding in factorial experiments; incomplete block designs; response surface methodology.

421. SURVEY DESIGNS FOR RESEARCH WORKERS.
(3-0) Cr. 3. S.SSII.
Prerequisite: 401.
Methods of constructing and analyzing designs for survey investigations; simple random, stratified, multistage, and multiphase sampling designs; questionnaire construction; methods of estimation; techniques of survey investigation.

431. ELEMENTARY STATISTICAL QUALITY CONTROL.
(3-0) Cr. 3. S.
Prerequisite: 101 or 401.
Application of statistical principles to manufacturing. Survey of control chart technique and sampling inspection schemes now in use.

436. GENETIC STATISTICS FOR RESEARCH WORKERS.
(3-0) Cr. 3. S.
Prerequisite: 411.
Statistical concepts in quantitative genetics. Derivation, definition, and estimation of genetic parameters. Application of statistical models to the design, analysis, and interpretation of quantitative genetic experiments. Genetic and statistical implications of common selection procedures.

447, 448. STATISTICAL THEORY FOR RESEARCH WORKERS.
(3-0) Cr. 3 each. 447: W.SSI; 448: S.SSII.
Prerequisite: 447: 446 or Math. 112; 448: 447.
Primarily for graduate students not majoring in statistics. Emphasis on the aspects of the theory underlying statistical methods. Probability, population distribution functions and their properties, sampling distributions, orthogonal linear functions, estimation, tests of hypotheses, regression.

481. PROCESSING OF STATISTICAL DATA.
(Com.S. 481) (2-0) Cr. 2. W.
Prerequisite: 401, Com.S. 201.
Introduction to programming statistical analyses for research problems. Not open for credit to students who have had 380.

482. PROCESSING OF STATISTICAL DATA.
(Com.S. 482) (2-0) Cr. 2. S.
Prerequisite: 402, and 380 or 481.
Use of high-speed electronic computers in problems in statistical analysis. Programming techniques include assembly and compiler routines.

490. SPECIAL PROBLEMS.
Cr. var.
Prerequisite: Fifteen credits in statistics.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

501. INTERMEDIATE STATISTICAL METHODS.
(3-0) Cr. 3. F.
Prerequisite: 402. Bancroft.
Special situations in the analysis of variance; multiple comparisons; transformations; multiple covariance; fitting of polynomials and nonlinear regression; extension of chi-square applications.

505. PSYCHOMETRICS.
(Psych. 505) (3-0) Cr. 3. S.
Prerequisite: 402, Psych. 440. Wolins.
Theories of psychological scaling and measurement; derivation of formulas used in reliability experiments; useful approximation procedures.

506. FACTOR ANALYSIS.
(Psych. 506) (3-0) Cr. 3. F.
Prerequisite: 505. Wolins.
Derivation of procedures from the general model of factor analysis. Thurstone's, Hotelling's, and Lawley's factorial methods. Criteria for significance of factor loadings and for testing for minimum rank. Factor rotation.

508. SOCIOMETRIC STATISTICS.
(3-0) Cr. 3. F.
Prerequisite: 402. Warren.
Sociological models, including linear models, and their application to sociological data. Criterion variables, selection of predictor variables, estimation, dummy variables, residuals, and causal inferences. Methods of sociological scaling, index construction, and composite measures.

511, 512. DESIGN OF EXPERIMENTS.
(3-0) Cr. 3 each. 511: W; 512: S.
Prerequisite: 401, 448 or 541. Zyskind.
Intermediate theory of least squares; classificatory and functional models, estimability, missing observation procedures and the analysis of variance and covariance. Principles of statistical design for experimental investigations in biological, agricultural, and industrial research; tests; estimation; randomized blocks; Latin-squares; Graeco-Latin squares; 2_n, 3_n, and other factorial systems; fractional replication; simple split-plot trials; introduction to quasi-factorial and incomplete block designs; determination of optima.

521, 522. DESIGN OF SURVEYS.
(3-0) Cr. 3 each. 521: W; 522: S.
Prerequisite: 521: 401, and 448 or 541; 522: 521. Han, B.V. Sukhatme.
Comprehensive account of sampling theory as developed for use in sample surveys; simple random, stratified, systematic, cluster, and multistage sampling; methods of estimation, including ratio and regression techniques; nonsampling errors; descriptive vs. analytical surveys.

531. INDUSTRIAL STATISTICS: PROCESS CONTROL.
(I.E. 531) (3-0) Cr. 3. Alt. F, offered 1972.
Prerequisite: 343 or 448. Mensing.
Sequential analysis; continuous sampling plans; statistical process control; cost functions and Bayes procedures.

533. INDUSTRIAL STATISTICS: RELIABILITY.
(I.E. 533) (3-0) Cr. 3. Alt. F, offered 1971.
Prerequisite: 343 or 448. Mensing.
Probabilistic aspects of reliability models; inference for reliability parameters; design of multicomponent systems; replacement and inspection policies.

535. BIOLOGICAL STATISTICS.
(3-0) Cr. 3. S.
Prerequisite: 402. C.P. Cox.
Direct and indirect biological assay; dose response curve; parallel line and slope ratio assay; crossover design; multiple assays; quantal responses; probit analysis.

536, 537. GENETIC STATISTICS.
(Gen. 536, 537) (3-0) Cr. 3 each. 536: Alt. F, offered 1972; 537: Alt. W, offered 1973.
Prerequisite: 402, 448, Gen. 301; or Gen. 460, permission of instructor. Pollak.
Probability applied to genetic systems; theory of inbreeding; estimation of genetic parameters and testing of genetic hypotheses; models for quantitative inheritance; partition of genotypic variance; covariances among relatives with random mating and with selfing; experimental designs for evaluating parameters; phenotypic selection for quantitative traits.

538. ECONOMETRIC STATISTICS.
(Econ. 538) (3-0) Cr. 3. F.
Prerequisite: 448. Fuller.
Generalized linear regression models, dummy variables; miscellaneous estimation problems, autocorrelated errors, errors in variables, multicolinearity; estimation of parameters in simultaneous equation systems.

539. OPERATIONS RESEARCH.
(Econ. 539) (I.E. 539) (3-0) Cr. 3. W.
Prerequisite: 343 or 448. Mensing.
Topics in game theory, programming, and the theory of queues.

540. OPERATIONS RESEARCH METHODS AND ECONOMIC ANALYSIS.
(Econ. 540) (I.E. 540) (3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: 446 or Math. 112, and Econ. 537 or Stat. 539. Sengupta.
Techniques of inventory control and management; other types of control, forecasting, and optimization techniques; methods of simulation and sensitivity programming and their economic applications; programming under risk in dynamic models of transportation, allocation, and replacement; dynamic and recursive programming; methods of quantitative planning of economic policy.

541, 542, 543. THEORY OF PROBABILITY AND STATISTICS.
(3-0) Cr. 3 each. Yr.
Prerequisite: 541: Math. 409 or 414; 542: 541, and Math. 410 or 415; 543: 542. Arnold, Meeden.
Development of distribution theory from the theory of probability; common distribution functions; derivation of sampling distributions with particular attention to normal populations; estimation by maximum likelihood; likelihood ratio tests of parametric hypotheses; introduction to general linear hypothesis theory; elements of sequential analysis; distribution free methods.

544. **STATISTICAL DECISION THEORY.**
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: 539. David.
Admissibility and completeness; decision functions; Bayes and minimax solutions; sequential and nonsequential cases; utility and principles of choice.

545. **STOCHASTIC PROCESSES.**
(3-0) Cr. 3. SSII.
Prerequisite: 541. Arnold.
Stationary processes with emphasis on the time domain; transformations and derived processes; normal and Poisson processes; renewal theory; Markov chains; harmonic analysis of processes.

546. **NONPARAMETRIC STATISTICAL THEORY.**
(3-0) Cr. 3. S.
Prerequisite: 542. S. Sukhatme.
Introduction to nonparametric problems; one-sample, two-sample, and c-sample problems; order statistics and their applications; rank tests, tests for location and dispersion and their large sample properties; tests based on sample distribution functions; asymptotic relative efficiency of nonparametric tests.

549. **MATHEMATICAL PROGRAMMING.**
(3-0) Cr. 3. S.
Prerequisite: 539 or Econ. 537; one course in computer programming. Sposito.
Techniques for determining the optima of linear and nonlinear models including linear, integer, quadratic, convex, and geometric programming applied to economic, engineering, and statistical problems.

554, 555. **PROBABILITY.**
(Math. 554, 555) See Mathematics.

580. **STATISTICAL COMPUTATIONS ON DIGITAL COMPUTERS I.**
(Com.S. 580) (3-0) Cr. 3. W.
Prerequisite: 402; 342 or 448 or 542; Math. 307, Com.S. 201 or knowledge of Fortran. Kennedy.
Programming techniques and methods for solution of problems in multiple linear regression, nonlinear regression, analysis of variance.

581. **STATISTICAL COMPUTATIONS ON DIGITAL COMPUTERS II.**
(Com.S. 581) (3-0) Cr. 3. S.
Prerequisite: 580, and Math. 409 or 414. Kennedy.
Topics in the use of digital computers for theoretical investigations in statistics; evaluating statistical distribution functions, Monte Carlo techniques, programming symbolic operations.

590. **SPECIAL TOPICS.**
Cr. var.
A. Theory.
B. Methods.
C. Design of Experiments.
D. Design of Surveys.

COURSES FOR GRADUATE STUDENTS, major or minor

601. **ADVANCED STATISTICAL METHODS.**
(3-0) Cr. 3. F.
Prerequisite: 501, and 448 or 543. C.P. Cox.
Principles of regression analysis; general orthogonal polynomials; multivariate analysis including Hotelling's T_2, the linear discriminant function and the analysis of dispersion; regression nonlinear in the parameters; seminars on special topics.

608. **SEMINAR ON STATISTICAL METHODS.**
Cr. var.
Prerequisite: 501; 448 or 543.

611, 612. **ADVANCED DESIGN OF EXPERIMENTS.**
(3-0) Cr. 3 each. 611: Alt. W; 612: Alt. S, offered 1973.
Prerequisite: 512, 641. Kempthorne.
Randomization theory of designs; general theory of factorial designs; fractional replication; theory of quasifactorial and incomplete block designs; analysis of groups of experiments; treatments applied in sequence; designs for determining optima.

621. **ADVANCED DESIGN OF SURVEYS.**
(3-0) Cr. 3. Alt. W, offered 1972.
Prerequisite: 522, 543. Han, B.V. Sukhatme.
Advanced topics in sampling theory as used in survey design; unequal probability sampling with and without replacement; unbiased ratio and regression type estimators; analytical treatment of nonsampling errors.

622. **SEMINAR ON DESIGN OF SURVEYS.**
Cr. var. Alt. S, offered 1972.
Prerequisite: 621. Han, B.V. Sukhatme.
Special topics of current interest in design of surveys; review of recent literature.

638. **ADVANCED ECONOMETRIC STATISTICS.**
(Econ. 638) (3-0) Cr. 3. Alt. W, offered 1972.
Prerequisite: 538. Fuller.
Simultaneous equation systems of economic relationships: Identification, methods of estimation, and computational layout. Distributed lag models. Problems of specification, aggregation, and prediction in econometric analysis.

639. **STOCHASTIC AND CONTINUOUS PROGRAMMING.**
(3-0) Cr. 3. Alt. F, offered 1971.
Prerequisite: 539, 543. David.
Distributions of game values and program optima. Generalized Tchebycheff inequalities and continuous programs.

641. **GENERAL THEORY OF LINEAR HYPOTHESIS.**
(3-0) Cr. 3. F.
Prerequisite: 543, Math. 307. Zyskind.
Theory of least squares; theory of general linear hypothesis; analysis of multiple classification data; components of variance.

642. **PROBABILITY AND DISTRIBUTION THEORY.**
(3-0) Cr. 3. W.
Prerequisite: 543, Math. 514.
Probability measure and distribution functions; random variables; characteristic functions; asymptotic distributions.

643. **THEORY OF ESTIMATION AND TESTING OF HYPOTHESES.**
(3-0) Cr. 3. S.
Prerequisite: 543.
Neyman-Pearson theory of testing hypotheses; point and interval estimation; sufficient statistics; elements of decision theory.

644. **SEQUENTIAL STATISTICAL DECISION THEORY.**
(3-0) Cr. 3. Alt. F, offered 1972.
Prerequisite: 543, 544, one course in probability. David.
Several-source sequential analysis, optimal stop rules, Markovian sequential decision models.

646. **TIME SERIES.**
(Econ. 646) (3-0) Cr. 3. Alt. S, offered 1973.
Prerequisite: 448 or 543. Fuller.
Stochastic processes; covariance and spectral representations; moving average and auto-regressive schemes; Fourier and periodogram analyses; serial correlations; analysis of trend, seasonal variations, and cyclical variations; method of variate differences.

647. **MULTIVARIATE ANALYSIS.**
(3-0) Cr. 3. F.
Prerequisite: 543, Math. 307. Han.
Multivariate normal distribution, Wishart distribution, Hotelling's T , multivariate regression analysis, discriminant functions.

648. **SEMINAR ON THE THEORY OF STATISTICS AND PROBABILITY.**
Cr. var.
Prerequisite: 543.

649. **RECENT DEVELOPMENTS IN STATISTICS AND PROBABILITY.**
(3-0) Cr. 3.
Prerequisite: 642, 643.
Material selected from an area of research such as sequential analysis, decision theory, nonparametric inference, stochastic processes.

661. **THEORIES OF INFERENCE.**
(3-0) Cr. 3. SSI.
Prerequisite: 543, one 600-level course in statistics. Kempthorne.
Review of basic aspects, condensation of data, sufficiency, the likelihood function, Bayes' theorem, past rejection of Bayesian processes, statistical tests, problems and obscurities, statistical intervals, problems of validity, likelihood inference, recent Bayesian inference, review of basic writings.

680. **SEMINAR ON STATISTICAL COMPUTATIONS.**
Cr. var. F.
Prerequisite: 581, permission of instructor.
Computational aspects of the research topics of those individuals enrolled in the course. Algorithms for the solution of theoretical and applied problems in statistics.

699. **RESEARCH.**

TEXTILES AND CLOTHING

Margaret C. Warning, Ph.D., Head of Department

The Graduate Faculty

Members: M.C. Warning, T.G. Winakor

Associate Members: M. DeLong, R.E. Hall, N.R. Hollen, A.L. Huepenbecker, C.J. Kundel

The department offers work for the degree Master of Science with major in textiles and clothing, and minor work to students taking major work in other departments.

Prerequisite to major graduate work is the completion of courses in applied art, chemistry (including inorganic and organic), economics, textiles and clothing (including specific courses in general textiles, clothing construction, and costume designing). Additional prerequisites may be required, depending upon the nature of the work the student wishes to pursue.

The foreign language requirement will be established at the discretion of the student's advisory committee.

COURSES FOR GRADUATE STUDENTS, minor only

404. **ADVANCED TEXTILES.**
(3-0) Cr. 3. F.W.S.
Prerequisite: 304, Chem. 231, 232B.
New developments in the textile field as reported in current literature.

410. **TEXTILES AND CLOTHING DEPARTMENT SEMINAR.**
(2-0) Cr. 1. S.

414. **HISTORIC TEXTILES.**
(3-0) Cr. 3. F.W.S.SSI.
Prerequisite: 104, Hist. 202.
Development of textiles from ancient times; a study of specific historic textiles; contemporary interpretations of historic textile designs.

429. **CUSTOM TAILORING.**
(2-6) Cr. 4. F.W.S.SS.
Prerequisite: 225.
Custom tailoring techniques applied in making women's suits and coats.

454. **HISTORY OF COSTUME.**
(3-0) Cr. 3. F.S. Alt. SSI, offered 1973.
Prerequisite: Hist. 202.
Styles of costume in western civilization from ancient times to the present day; cultural and economic factors associated with the development, adoption, and abandonment of styles.

464. **FAMILY CLOTHING CONSUMPTION.**
(3-0) Cr. 3. F.W.S. Alt. SSI, offered 1972.
Prerequisite: 304, Econ. 241, 242.
Current theories of clothing consumption; factors affecting family clothing expenditure; production and distribution of textile and clothing products for the consumer market.

465. INTRODUCTION TO SOCIOLOGICAL AND PSYCHOLOGICAL ASPECTS OF CLOTHING AND TEXTILES.
(3-0) Cr. 3. F.W.S.
Prerequisite: 104, 245, Psych. 101, Soc. 134.
Origins and functions of clothing and textiles for individuals and societies, primitive and modern.

490. SPECIAL PROBLEMS.
Cr. 1 to 4 per quarter.
Prerequisite: Ten credits in textiles and clothing, permission from the department head and instructor.
A. Textiles.
B. Historic Textiles.
C. Clothing Construction.
D. Costume Design.
E. History of Costume.
F. Sociological and Psychological Aspects of Textiles and Clothing.
G. Economic Aspects of Clothing.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

500. SHORT COURSE.
Cr. arr. SS.

501. INTERNATIONAL STUDY TOUR.
Cr. 1 to 8. SS.
Prerequisite: 414 or 454 or equivalent.
A short period of orientation (lectures, films, discussion, short field trips, and study) before travel to observe garments and textiles in mills, factories, homes, stores, laboratories, and museums. Countries studied and visited will vary.

504. EXPERIMENTAL TEXTILES.
(2-4) Cr. 3. S.
Prerequisite: 404.
Experience in planning, executing, and reporting introductory studies in textile research; review of pertinent literature and testing of fabrics using equipment available.

523. EXPERIMENTAL CLOTHING CONSTRUCTION.
(2-4) Cr. 3. W.
Prerequisite: 225 or graduate standing. Saddler.
Experimental approach to the study of factors influencing sewing construction; evaluation of sewing techniques.

525. ADVANCED DRAPING.
(2-4) Cr. 3. S.SS.
Prerequisite: 225, 345. Shibles, Burton.
Application of design and pattern-making principles to various fabrics and styles.

528. THEORY OF PATTERN DRAFTING AND DESIGNING.
(3-6) Cr. 3. F.S.SSI.
Prerequisite: 225. Hollen, Kundel.
Analytical study of commercial pattern characteristics. Drafting of personal basic pattern or "block" and application of drafting principles to a figure with fitting problems. Pattern designing on the drafted "block."

529. EXPERIMENTAL TAILORING.
(2-6) Cr. 4. W.
Prerequisite: 429 or equivalent. Kundel.
Study of an experimentation in tailoring techniques as applied to various fabrics used in coats and suits.

544. ADVANCED COSTUME DESIGN.
(2-4) Cr. 3. W.S.SSI.
Prerequisite: 345. DeLong.
A visual and theoretical analysis of the costume-body form; application of this analysis to specific group and individual design problems.

554. ADVANCED HISTORY OF COSTUME.
(2-0) Cr. 2-3. W.
Prerequisite: 454. Winakor.
Study of garments in the historic collection and their relationship to other sources of information; research techniques; individual study of selected periods.

565. THE SOCIOLOGICAL AND PSYCHOLOGICAL ASPECTS OF CLOTHING AND TEXTILES.
(3-0) Cr. 3. W.SS.
Prerequisite: 465. Warning, Hall.
Readings in and investigation of social and psychological aspects of clothing and textiles. Written and oral reports of research and readings.

590. SPECIAL TOPICS.
Prerequisite: Permission of the department head and professor or professors concerned.
A. Textiles.
B. Historic Textiles.
C. Clothing Construction.
D. Costume Design.
E. History of Costume.
F. Socio-psychological Aspects of Textiles and Clothing.
G. Economic Aspects of Clothing.

COURSES FOR GRADUATE STUDENTS, major or minor

610. SEMINAR.
Cr. arr. W. Winakor.

699. RESEARCH.

VETERINARY ANATOMY

The Graduate Faculty

Members: N.R. Cholvin, G.C. Christensen, R.L. Kitchell

Associate Members: N.G. Ghoshal, J.H. Magilton, B.H. Skold

The department offers work for the degrees Master of Science and Doctor of Philosophy with major in veterinary anatomy, and minor work for students majoring in other departments. Within the veterinary anatomy major the student may specialize in microscopic anatomy and macroscopic anatomy.

Instruction and research facilities in biomedical engineering are provided jointly by the departments of Electrical Engineering, Veterinary Anatomy, and Veterinary Physiology and Pharmacology. See *Biomedical Engineering* for requirements.

Prerequisite to major graduate work is the completion of an undergraduate curriculum substantially equivalent to that in veterinary medicine.

Research is encouraged in gerontology, experimental neuroanatomy, advanced veterinary microscopic organology, surgical anatomy, advanced anatomy for biomedical engineering, gross anatomy, and ultrastructure of cells and tissues.

COURSES FOR GRADUATE STUDENTS, minor only

401. ADVANCED MICROSCOPIC ANATOMY.
(2-8) Cr. 5. F.
Prerequisite: One year of college biology.
Cytology, basic tissues, and developmental anatomy.

402. ADVANCED MICROSCOPIC ANATOMY.
(3-6) Cr. 5. W.
Prerequisite: 401.
The body systems and organogenesis.

403. ADVANCED MICROSCOPIC ANATOMY.
(1-10) Cr. 4. S.
Prerequisite: 402.
The body systems, endocrines, and fetal membranes.

404. SYSTEMATIC ANATOMY.
(1-6 or 12) Cr. 3 or 5 each time taken. SS.
Prerequisite: One year of college biology, permission of instructor.
A. Ruminant Anatomy. **Cr. 5.**
B. Nonruminant Anatomy. **Cr. 5.**
C. Anatomy for Biomedical Engineering. **Cr. 3.**
D. Avian Anatomy. **Cr. 3.**

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

510. ENDOCRINOLOGY.
(V.Phys. 510) (4-3) Cr. 5. Alt. S, offered 1973.
Prerequisite: Permission of instructor. Swenson.
Embryology, structure and function of endocrine organs.

511. NEUROANATOMY.
(V.Pth. 511) (2-0 or 2-6) Cr. 2 or 4. Alt. W, offered 1972.
Prerequisite: Permission of instructor. Ghoshal, Kitchell, Ramsey, Skold.
Central and peripheral nervous system including the organs of special sense.

561. COMPARATIVE MAMMALIAN ANATOMY AND PHYSIOLOGY.
(V.Phys. 561) (B.M.E. 561) (3-3) Cr. 4. F.
Prerequisite: Credit or classification in B.&B. 304 or 404.
Integrated teaching approach for graduate students who have had little or no previous training in anatomy and physiology. Designed for students in animal nutrition, biochemistry, engineering, food and nutrition, psychology, and other biological sciences. Same applies to 562 and 563. Cellular structure and function, nervous system, sensory systems, and muscle systems.

562. COMPARATIVE MAMMALIAN ANATOMY AND PHYSIOLOGY.
(V.Phys. 562) (B.M.E. 562) (4-3) Cr. 5. W.
Prerequisite: Credit or classification in B.&B. 305 or 405.
Cardiovascular system, respiration, acid-base balance, and renal system.

563. **COMPARATIVE MAMMALIAN ANATOMY AND PHYSIOLOGY.**
(V.Phys. 563) (B.M.E. 563) (3-3) Cr. 4. S.
Prerequisite: B.&B. 305 or 405.
Digestion, metabolism, reproduction and endocrine systems.

590. **SPECIAL TOPICS.**
Cr. 2 to 5 each time elected.
Prerequisite: Fifteen credits of acceptable graduate work, permission of instructor.
A series of nonsequence courses selected from the following topics:
A. Ultra Structure of Animal Tissues.
B. Techniques in Electron Microscopy.
C. Gerontology of Domestic Animals.
D. Special Problems in Gross Anatomy.
E. Special Problems in Microscopic Anatomy.
F. Anatomy of Laboratory Animals. **SS.**
G. Anatomical Techniques. **SS.**

COURSES FOR GRADUATE STUDENTS, major or minor

604. SEMINAR.
Cr. 1. F.W.S.SS.

699. **RESEARCH.**
A. Gross Anatomy.
B. Microscopic Anatomy.

VETERINARY CLINICAL SCIENCES

Wallace M. Wass, D.V.M., Ph.D., Head of Department

The Graduate Faculty

Members: M.A. Emmerson, G.R. Fowler, P.T. Pearson, W.M. Wass

Associate Member: R.L. Lundvall

The department offers work for the degree Master of Science with major in Veterinary Clinical Science, and minor work for students majoring in other departments. Within the Veterinary Clinical Sciences major, the student may specialize in veterinary medicine, surgery, radiology, or reproductive diseases.

Both thesis and nonthesis options are available.

Prerequisite to major graduate work is graduation from an approved College of Veterinary Medicine.

COURSE PRIMARILY FOR GRADUATE STUDENTS, major or minor

590. **SPECIAL TOPICS.**
Cr. 1 to 5.
Prerequisite: Permission of instructor.

COURSES FOR GRADUATE STUDENTS, major or minor

604. **SEMINAR.**
Cr. 1. F.W.S.

640. **ADVANCED RADIOLOGY.**
(2-3 or 9) Cr. 3 or 5. F.W.S.
Prerequisite: 440. Emmerson.
Detailed principles of clinical radiology with particular reference to radiographic interpretation.

644. **ADVANCED ANIMAL REPRODUCTION.**
(2-3) Cr. 3. Alt. W, offered 1973.
Prerequisite: 447, 450. Wagner.
Male reproduction. Will include infectious diseases affecting male fertility, and male endocrinopathies and physiologic abnormalities affecting spermatogenesis and fertility.

645. **ADVANCED ANIMAL REPRODUCTION.**
(2-3) Cr. 3. Alt. W, offered 1972.
Prerequisite: 447, 450. Wagner.
Female reproduction. Will include postpartum physiopathology, corpus luteum function, environmental effects, and adrenal and thyroid role in reproduction. Emphasis on experimental case material and discussion of literature.

671. **ADVANCED GENERAL SURGERY.**
(2-3 or 9) Cr. 3 or 5. F.W.S.
Prerequisite: 442. Pearson.
An advanced course designed to investigate and discuss the responses of the body to surgical and anesthetic procedures.

672. **ADVANCED SPECIAL SURGERY.**
(2-3 or 9) Cr. 3 or 5. F.W.S.
Prerequisite: 442. Pearson.
Advanced procedures in both clinical and research techniques are offered in abdominal, thoracic, orthopedic, cardiovascular, and neurological surgery.

676. **ADVANCED MEDICINE.**
(2-3 or 9) Cr. 3 or 5. Alt. W, offered 1972.
Prerequisite: 446. Wass.
Principles of general medicine. A study in depth of factors that contribute to the development of clinical signs as related to the pathogenesis of disease.

677. **ADVANCED MEDICINE.**
(3 or 5-0) Cr. 3 or 5. Alt. S, offered 1973.
Prerequisite: 446. Wass.
An advanced study of metabolic diseases.

678. **LABORATORY ANIMAL MEDICINE.**
(3-0) Cr. 3. Alt. SS, offered 1973.
Prerequisite: 446. Flatt.
Detailed principles of medicine and pathology of laboratory animals.

699. **RESEARCH.**

VETERINARY MICROBIOLOGY AND PREVENTIVE MEDICINE

R. Allen Packer, D.V.M., Ph.D., Head of Department

The Graduate Faculty

Members: R.E. Dierks, M.S. Hofstad, M.L. Kaeberle, C.A. Manthei, L.O. Mott, R.A. Packer, A.C. Pier, R.F. Ross, W.P. Switzer

Associate Members: M.L. Frey, P.M. Gough, C.J. Maré, E.E. Wedman

The department offers work for the degree Master of Science with majors in veterinary microbiology and veterinary preventive medicine, work for the degree Doctor of Philosophy with major in veterinary microbiology, and minor work to students taking major work in other departments.

Prerequisite to major graduate work is the possession of the D.V.M. degree or the completion of an undergraduate program in biological science with emphasis in microbiology.

COURSES FOR GRADUATE STUDENTS, minor only

381. **GENERAL BACTERIOLOGY AND IMMUNOLOGY.**
(3-9) Cr. 6. F.
Prerequisite: B.&B. 304, 305.
Morphology, classification, and physiological characteristics of pathogenic bacteria; principles of infection and immunity.

382. **PATHOGENIC BACTERIOLOGY.**
(4-6) Cr. 6. W.
Prerequisite: 381, V.Pth. 371.
Detailed study of bacteria associated with animal diseases.

383. **VIROLOGY AND PRINCIPLES OF EPIDEMIOLOGY.**
(4-4) Cr. 5. S.
Prerequisite: 381, V.Pth. 371.
Characteristics of the viruses which infect animals; mechanisms of infection and techniques used in the study of viruses. Principles of epidemiology as applied to the infectious diseases of animals.

431, 432, 433. **INFECTIOUS DISEASES AND PREVENTIVE MEDICINE.**
(3-0) Cr. 3 each. F.W.S.
History, etiology, epidemiology, laboratory diagnosis, regulatory control, public health and preventive medical aspects of the infectious diseases of animals.

484. **PUBLIC HEALTH I.**
(3-0) Cr. 3. F.
Principles of public health practice; epidemiology of food-borne illnesses and public health standards for the sanitary production of milk and milk products.

485. **PUBLIC HEALTH II.**
(3-0) Cr. 3. W.
Federal and state laws, regulations and procedures governing slaughter and/or processing of meat food animals and food products of animal origin, methods of inspection, and criteria for acceptability.

487. **LIVESTOCK DISEASE PREVENTION.**
(3-0) Cr. 3. S.
Prerequisite: Bact. 300.
A survey of diseases of large domestic animals, including a discussion of the causes, transmission, processes, and control. Designed for students majoring in agricultural sciences.

488. **POULTRY DISEASE PREVENTION.**
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: Bact. 300.
A survey of diseases of poultry including a discussion of the causes, transmission, processes, and control. Designed for students majoring in animal science with an interest in poultry.

490. **SPECIAL PROBLEMS.**
(1-5) Cr. arr.
Prerequisite: Permission of department head.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

509. GENERAL VIROLOGY.
(Bact. 509) See Bacteriology.

520. SEROLOGY.
(Imbio. 520) (2-6) Cr. 4. F.
Prerequisite: 381 or Bact. 300. Kaeberle.
Principles of serology as applied to the diagnosis of infectious diseases and research in immunology.

522. PRINCIPLES OF EPIDEMIOLOGY.
(3-0) Cr. 3. S.
Prerequisite: 382, 383.
Factors which influence the spread and perpetuation of animal diseases in animal and human populations.

526. ADVANCED VETERINARY VIROLOGY.
(3-4) Cr. 5. Alt. W, offered 1972.
Prerequisite: 383 or 509, permission of instructor. Maré.
The study of pathogenesis and ecology of viral infections and the procedures for diagnosis and control of viral diseases.

590. SPECIAL TOPICS.
Cr. 1 to 5.
Prerequisite: 382.

COURSES FOR GRADUATE STUDENTS, major or minor

604. SEMINAR.
(1-0) Cr. 1. F.W.S. Packer.

625. PATHOGENIC BACTERIOLOGY.
(3-6) Cr. 5. SS.
Prerequisite: 381, 382. Packer.
Advanced study of the pathogenic bacteria and technical procedures used in research.

626. BASIC MECHANISMS IN ANIMAL VIROLOGY.
(3-4) Cr. 5. Alt. W, offered 1973.
Prerequisite: 509 or 526; B.&B. 405, permission of instructor. Maré.
Advanced study of animal virus host-cell interactions and technical procedures utilized in animal virus research.

629. MEDICAL IMMUNOLOGY.
(Imbio. 629) (3-6) Cr. 5. W.
Prerequisite: 520, 10 quarter credits in biochemistry, permission of instructor. Kaeberle.
Mechanisms of resistance to disease including natural and acquired immunity. Nature of immune substances, their production and role in health and disease.

699. RESEARCH.

VETERINARY PATHOLOGY

Frank K. Ramsey, D.V.M., Ph.D., Head of Department

The Graduate Faculty

Members: W.B. Buck, J.H. Greve, E.L. Jeska, W.S. Monlux, J.J. O'Toole, F.K. Ramsey, L.H. Schwarte, W.J. Zimmerman

Associate Members: R.A. Ball, N.F. Cheville, N.E. Hutton, R.L. Kemp, J.P. Kluge, W.R. Richter, V.A. Seaton, M.W. Sloss, G.A. VanGelder

The department offers work for the degrees Master of Science and Doctor of Philosophy with major in veterinary pathology, and minor work for students majoring in other departments. Within the veterinary pathology major the student may specialize in veterinary parasitology and veterinary toxicology.

A satisfactory reading knowledge of one language is strongly recommended for the Master of Science degree. A satisfactory reading knowledge of two languages or a comprehensive knowledge of one language is strongly recommended for the Ph.D. degree. For students whose native language is not English, the ability to communicate adequately in English (certified by the Department of English) may be acceptable as a substitution for the reading knowledge of one foreign language. The department uses the standardized examinations provided by Educational Testing Service and administered by the University for determining the proficiency of the reading knowledge of a student in a foreign language.

It is possible to study for the degree Master of Science on a nonthesis basis. This option requires the completion of a minimum of 50 graduate credits, of which at least 15 must be earned in course work outside the department. The degree Master of Science with thesis requires the completion of a minimum of 45 graduate credits.

Prerequisite to major graduate work is the completion of an undergraduate curriculum leading to the degree Doctor of Veterinary Medicine.

Minor work is recommended in other departments of the College of Veterinary Medicine, and in bacteriology, biochemistry, cell biology, chemistry, zoology, entomology, physics, botany, genetics, psychology, or education.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

511. **NEUROANATOMY.**
(V.An. 511) (2-0 or 6) Cr. 2 or 4. Alt. F, offered 1972.
Prerequisite: Permission of instructor. Getty, Ramsey.
Central and peripheral nervous systems including the organs of special sense.

551. **GENERAL PATHOLOGY.**
(3-4) Cr. 5. F.
Prerequisite: V.An. 303, 313, or permission of instructor. Ramsey.
Fundamentals of disease with emphasis on disease in animals.

554. **VETERINARY TOXICOLOGY.**
(3-0 or 4) Cr. 3 or 5. S.
Prerequisite: 371. Buck, Van Gelder.
Disease processes in animals caused by toxicants, differential diagnostic procedures, and identification of toxicants by laboratory tests.

557, 558. **VETERINARY PARASITOLOGY.**
557: (3-3) Cr. 4. W; 558: (4-3) Cr. 5. S.
Prerequisite: 557: Permission of instructor; 558: 557. Greve, Kemp.
Problems of parasitism in relation to animals.

590. **SPECIAL TOPICS.**
Cr. 1 to 5. F.W.S.
Prerequisite: 423.
Special topics in the field of veterinary pathology and parasitology.

COURSES FOR GRADUATE STUDENTS, major or minor

604. **SEMINAR.**
Cr. 1. F.W.S.SS.

653. **CELLULAR PATHOLOGY.**
(3-0 or 4) Cr. 3 or 5. Alt. F, offered 1973.
Prerequisite: 423. Kluge.
Fundamentals involved in the pathogenesis of disease processes.

654. **VETERINARY NEUROPATHOLOGY.**
(3-6) Cr. 5. Alt. S, offered 1973.
Prerequisite: 511, 653. Ramsey.
Advanced study of diseases of the nervous system.

655. **PHYSIOPATHOLOGY OF THE SKELETAL SYSTEM.**
(3-0 or 4) Cr. 3 or 5. Alt. W, offered 1973.
Prerequisite: 653.
An advanced study of the nutritional and infectious diseases of bones and joints of animals.

656. **ADVANCED VETERINARY PATHOLOGY.**
(1-3 to 12) Cr. 2 to 5. F.W.S.
Prerequisite: 377, 423.
A. Experimental Pathology.
B. Experimental Parasitology.
C. Advanced Post-Mortem Techniques.
D. Pathologic Hematology.
E. Mycotic and Parasitic Granulomatous Diseases. **Ramsey.**
F. Neoplasms of Domestic Animals. **Kluge, Ramsey.**

657. **ADVANCED VETERINARY TOXICOLOGY.**
(1-3 to 12) Cr. 2 to 5. Alt. F, offered 1972.
Prerequisite: 554, 653, or permission of instructor. Buck, Van Gelder.
Advanced study of specific toxicants as related to animal diseases, public health hazards, and the chronic effects of agricultural chemicals on animal tissues.

659. **ADVANCED VETERINARY PARASITOLOGY.**
(1-3 to 12) Cr. 2 to 5. F.W.S.
Prerequisite: 377, and 423, or 558. Greve, Kemp, Jeska, Zimmermann.
Introduction to research in animal parasitology.

660. **PATHOLOGY OF PARASITIC DISEASES.**
(2-6) Cr. 5. Alt. SS, offered 1972.
Prerequisite: 551. Greve, Kemp, Jeska, Zimmermann.
A study of the gross and microscopic tissue changes caused by parasites.

699. **RESEARCH.**
A. Veterinary Pathology.
B. Veterinary Parasitology.
C. Veterinary Toxicology.

VETERINARY PHYSIOLOGY AND PHARMACOLOGY

Melvin J. Swenson, D.V.M., Ph.D., Head of Department

The Graduate Faculty

Members: N.R. Cholvin, R.W. Dougherty, D.D. Gillette, R.L. Kitchell, M.J. Swenson, W.G. Van Meter, W.C. Wagner

Associate Members: F.A. Ahrens, D.B. Coulter, M.H. Crump, R.L. Engen, F.B. Hembrough, R.H. Kohlmeier, W.O. Reece

The department offers work for the degrees Master of Science and Doctor of Philosophy with major in physiology (domestic animals) and minor work for students majoring in other departments.

Any foreign language acceptable to the student's advisory committee is approved for the degree Doctor of Philosophy. A grade of 500 is required on the Educational Testing Service examination to meet the requirement. There is no language requirement for the degree Master of Science.

Instruction and research facilities in biomedical engineering are provided jointly by the departments of Electrical Engineering, Veterinary Anatomy, and Veterinary Physiology and Pharmacology. See *Biomedical Engineering* for requirements.

Students expecting to do major work should have fundamental knowledge of physiology, mathematics, zoology, anatomy, physics, and chemistry.

COURSES FOR GRADUATE STUDENTS, minor only

366. AVIAN PHYSIOLOGY.
(2-3) Cr. 3. Alt. W, offered 1972.
Prerequisite: 264.
Basic physiological processes in poultry with emphasis on the chicken.

367. PHARMACOLOGY AND THERAPEUTIC PRINCIPLES.
(4-3) Cr. 5. F.
Prerequisite: 318.
General principles of pharmacodynamics, including measurement, administration, distribution, receptor action, and elimination of drugs. Introduction to specific classes of drugs. Courses 367 and 368 are designed for veterinary students and non-DVM graduate students minoring in physiology.

368. PHARMACOLOGY.
(5-3) Cr. 6. W.
Prerequisite: 367.
Pharmacodynamics of drugs and their classes of importance in veterinary medicine.

490. SPECIAL PROBLEMS.
Cr. 1 to 5 each time taken.
Prerequisite: Permission of instructor.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

504. SEMINAR.
Cr. 1. W.
Prerequisite: Permission of instructor.
A student participation seminar in which graduate students present an oral and written review of an assigned topic.

510. ENDOCRINOLOGY.
(V.An. 510) (4-3) Cr. 5. Alt. S, offered 1973.
Prerequisite: Permission of instructor. Engen, Getty, Swenson.
Embryology, structure, and function of endocrine organs.

512. AUTONOMIC NERVOUS SYSTEM PHYSIOLOGY.
(3-3) Cr. 4. Alt. W, offered 1972.
Prerequisite: Permission of instructor.
Cellular considerations, neurotransmission, hypothalamus, cortical control, reflex arcs, control and regulation of internal functions and visceral organs.

513. CENTRAL NERVOUS SYSTEM PHYSIOLOGY.
(3-3) Cr. 4. Alt. W, offered 1973.
Prerequisite: Permission of instructor.
Cellular considerations, neurotransmission, reflex arcs, synaptic inhibition in brain and spinal cord, electroencephalography and evoked potentials, and sleep.

561. COMPARATIVE MAMMALIAN ANATOMY AND PHYSIOLOGY.
(V.An. 561) (B.M.E. 561) (3-3) Cr. 4. F.
Prerequisite: Credit or classification in B.&B. 304 or 404.
Integrated teaching approach for graduate students in basic anatomy and physiology. Designed for students in animal nutrition, biochemistry, engineering, food and nutrition, psychology, and other biological sciences. Same applies to 562 and 563. Cellular structure and function, nervous system, sensory systems, and muscle systems.

562. COMPARATIVE MAMMALIAN ANATOMY AND PHYSIOLOGY.
(V.An. 562) (B.M.E. 562) (4-3) Cr. 5. W.
Prerequisite: Credit or classification in B.&B. 305 or 405.
Cardiovascular system, respiration, acid-base balance, and renal system.

563. COMPARATIVE MAMMALIAN ANATOMY AND PHYSIOLOGY.
(V.An. 563) (B.M.E. 563) (3-3) Cr. 4. S.
Prerequisite: B.&B. 305 or 405.
Digestion, metabolism, reproduction, and endocrine system.

570. PHYSIOLOGY OF GESTATION.
(2-3) Cr. 3. Alt. W, offered 1973.
Prerequisite: Permission of instructor. Gillette.
Inception, maintenance, and termination of pregnancy with particular emphasis on control mechanisms.

590. SPECIAL TOPICS.
(1-5) Cr. 1 to 5.
Prerequisite: Permission of instructor.
Special work in instrumental methods, lactation, reproduction, psychotropic drugs, autonomic drugs, smooth muscle physiology, hematology, biochemistry of diseases, biomedical mathematics, or other subjects.

COURSES FOR GRADUATE STUDENTS, major or minor

660. DIGESTIVE PHYSIOLOGY.
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: Permission of instructor.
Neuromuscular characteristics of digestive tract, digestion, absorption, microbial digestion, and a comparative study of differences between ruminant and simple-stomached animals.

661. EXPERIMENTAL TECHNIQUES IN PHYSIOLOGY.
(2-6) Cr. 4. SS.
Prerequisite: 563 or Zool. 553. Hembrough, Pearson.
Study of basic physiology in animals with various fistulas, bypasses, and extirpations produced by surgical techniques.

699. RESEARCH.

WATER RESOURCES

Don Kirkham, Ph.D., Chairman, Advisory Committee

Advisory Committee: Roger W. Bachmann, Ph.D.; E.R. Baumann, Ph.D.; John D. Dodd, Ph.D.; Keith M. Hussey, Ph.D.; Howard P. Johnson, Ph.D.; Mary S. Pickett, Ph.D.; John F. Timmons, Ph.D.; Homer W. Walker, Ph.D.; Henry H. Webster, Ph.D.

Work is offered for the degrees Master of Science and Doctor of Philosophy with major in water resources under a cooperative arrangement with various departments including Agricultural Engineering, Agronomy, Bacteriology, Botany and Plant Pathology, Civil Engineering, Earth Science, Economics, Family Environment, Food Technology, Forestry, and Zoology and Entomology. Minor work is offered to students taking major work in other areas. Facilities exist in several departments for fundamental research in such areas as source, distribution, and movement of water (hydrology); hydraulics of water control facilities; physical, biological, and chemical properties of water (water quality); and economics of water resource development. For the nonthesis Master of Science degree, 52 quarter credits are required.

A student majoring in water resources will choose a major professor from the graduate faculty membership of the cooperating departments and will develop his program of study under the guidance of a committee nominated by the administrative department head, approved by the Water Resources Advisory Committee, and appointed by the dean of the Graduate College. For administrative purposes the student will be in the department of his major professor.

For the degrees Master of Science and Doctor of Philosophy, the foreign language requirement, if any, is established on an individual basis by the student's advisory committee.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

501. **WATER RESOURCES I.**
(3-0) Cr. 3. F.
Prerequisite: Permission of water resources advisory committee.
Introduction to water resources planning. Hydrology: source, distribution, and movement of water and hydraulics of water control facilities.

502. **WATER RESOURCES II.**
(3-0) Cr. 3. W.
Prerequisite: Permission of water resources advisory committee.
Water resources planning. The role of quality in water resources: physical, chemical, and biological aspects of water and waste water.

503. **WATER RESOURCES III.**
(3-0) Cr. 3. S.
Prerequisite: Permission of water resources advisory committee.
Water resources planning. Legal, government, socio-economic, administrative, and planning aspects of water resources.

590. **SPECIAL TOPICS.**
Cr. var.
Prerequisite: Permission of instructor.
Literature reviews and conferences in accordance with needs and interests of the student.

ZOOLOGY AND ENTOMOLOGY

Oscar E. Tauber, Ph.D., Chairman of Department

The Graduate Faculty

Members: F. Andre, R.W. Bachmann, T.A. Brindley, R.V. Bulkley, B.W. Buttrey, K.D. Carlander, P.A. Dahm, D.R. Griffith, W.D. Guthrie, A.O. Haugen, E.A. Hicks, J.L. Jarvis, H.H. Knight, J.L. Laffoon, R.E. Lewis, R.J. Muncy, J.A. Mutchmor, L.P. Pedigo, J.R. Redmond, W.A. Rowley, O.E. Tauber, M.J. Ulmer, M.W. Weller

Associate Members: J.R. Baker, G.G. Brown, W.D. Dolphin, C.J. Ellis, D.E. Harding, J.A. Klun, M.K. Petersen, K.C. Shaw, J.M. Viles, L.D. Wing

The department offers work for the degrees Master of Science and Doctor of Philosophy with majors in zoology, entomology, fisheries biology, and wildlife biology, and minor work in each of these fields. Within the appropriate major, the student may specialize in animal be-

havior, cytology, ecology, economic entomology, embryology (developmental biology), insect toxicology, limnology, medical entomology, morphology, parasitology, physiology, protozoology, and taxonomy.

Prerequisite to major and minor graduate work in the Department of Zoology and Entomology is the completion of at least two years of zoological courses, for part of which credit in other closely allied biological sciences may be substituted. Specific course requirements for advanced degrees depend partly upon previous training and experience in the major field of specialization.

Proficiency in one foreign language is required for the M.S. and Ph.D. The same language may serve for both degrees. The degree of proficiency may be demonstrated by one year of college credit with a minimal average of 2.0 (on a 4.0=A scale), by an Educational Testing Service Foreign Language Examination score of at least 500, or by committee approval of equivalent language experience. The student's advisory committee may require additional language competence.

Major and minor work in the area of cell biology is offered under cooperative arrangement with the departments of Bacteriology, Biochemistry and Biophysics, Botany and Plant Pathology, and Genetics. For description, see *Cell Biology*.

Zoology and Entomology is one of the cooperating departments in the biology program and in the water resources program. See *Biology* and *Water Resources*.

Graduate programs of the fisheries and wildlife section of the department are associated with the Iowa Cooperative Fisheries Research Unit, and the Iowa Cooperative Wildlife Research Unit. The European Corn Borer Laboratory at Ankeny is available for advanced study in certain phases of entomological research. Various graduate courses in zoology are taught during the summer, and special research projects are supervised at the Iowa Lakeside Laboratory, Lake Okoboji.

Index to field of work is given by the second and third figures of course numbers:

00-09 General Zoology
10-19 Parasitology
20-29 Anatomy
30-39 Embryology
40-49 Wildlife Biology
50-59 Physiology
60-69 Fisheries Biology
70-79 Entomology
90-99 Problems and Research

COURSES FOR GRADUATE STUDENTS, minor only

307. **INVERTEBRATE ZOOLOGY.**
(2-6) Cr. 4. S.SSI.
Prerequisite: 106, Biol. 103. Shaw.
Advanced study of invertebrates stressing classification, morphology, life history and evolutionary relationships.

324. **HISTOLOGICAL TECHNIQUES.**
(2-6) Cr. 4. W.S.SSI.
Prerequisite: 106; 322 recommended. Buttrey.
Methods of fixing, sectioning, mounting, and staining tissues for microscopic study.

401. **BIOLOGICAL ILLUSTRATION.**
(0-4) Cr. 2. W.
Prerequisite: Fifteen credits in biological sciences. Haupt.
Techniques and principles of biological illustration with emphasis on illustrating for scientific publications.

402. **ANIMAL ECOLOGY.**
(3-3) Cr. 4. F.S.
Prerequisite: Fifteen credits in biological sciences, including Biol. 103; Bot. 424 recommended. Wing.
Ecosystem, community, population, and habitat ecology of animals. Extended field trips.

405. **FUNDAMENTALS OF LIMNOLOGY.**
(2-3) Cr. 3. S.
Prerequisite: Fifteen credits in biological sciences or graduate classification. Bachmann.
Physical and chemical features of inland waters and their biological communities. Techniques of limnological surveys. Field trips.

428. **CELL BIOLOGY.**
(C.Bio. 428) See Cell Biology.

447. **MAMMALOGY.**
(2-6) Cr. 4. F.W.
Prerequisite: Biol. 103, Zool. 106; 320 recommended. Petersen.
Biology, identification, and classification of major groups of mammals. Field trips.

448. **WILDLIFE TECHNIQUES.**
(2-6) Cr. 4. S.
Prerequisite: 340, 402, 447, Bot. 424. Petersen.
Survey and evaluation of techniques used in research and management of game animals; laboratory and field work, including extended trips.

455. **PRINCIPLES OF PHYSIOLOGY.**
(2-6) Cr. 4. F.W.SSI.
Prerequisite: 106, Chem. 142, 142L; organic chemistry recommended. Redmond.
Introduction to systemic functions.

465. **FISHERIES MANAGEMENT.**
(3-3) Cr. 4. F.
Prerequisite: 405, 464. Carlander.
Concepts and practices relating to maintenance and improvement of fishery resources. Lake and stream surveys for evaluations as fish habitat. Field trips.

470. **ECONOMIC ENTOMOLOGY.**
(2-2) Cr. 3. W.
Prerequisite: 370. Dahm.
Contemporary concepts of insect biology and insect population management.

COURSES PRIMARILY FOR GRADUATE STUDENTS, major or minor

500. SEMINAR.
Cr. 1. F.W.S.
Prerequisite: Permission of instructor. Tauber.
Reports of research and current literature.

501. PRINCIPLES OF SYSTEMATIC ZOOLOGY.
(2-3) Cr. 3. Alt. W, offered 1973.
Prerequisite: Fifteen credits in zoology. Pedigo.
Historical development of classificatory systems, with discussions concerning the species concept, phylogenetic interpretation, numerical taxonomy, and nomenclature.

503. PRIMATE EVOLUTION.
(3-0) Cr. 3. S.
Prerequisite: Fifteen credits in zoology. Shaw.
Relationships and developmental history of primates.

504. ARACHNOLOGY.
(2-6) Cr. 4. Alt. S, offered 1973.
Prerequisite: Twenty credits in biological sciences. Hicks.
Biology, morphology, ecology, phylogenetic relationships, and economic importance of arachnids, especially mites, ticks, and spiders.

505. NEMATOLOGY.
(3-3) Cr. 4. Alt. S, offered 1972.
Prerequisite: Permission of instructor; 311 recommended. Ellis.
Biology of free-living and parasitic nematodes.

506. FREE-LIVING PROTOZOA.
(2-3) Cr. 3. Alt. S, offered 1972.
Prerequisite: Fifteen credits in zoology; 307 or 311 recommended. Buttrey.
Taxonomy, morphology, life history, ecology, genetics, biology, evolution, and identification of major groups of free-living Protozoa.

508L, 509L. AQUATIC ECOLOGY.
(See list of courses offered at the Iowa Lakeside Laboratory.)

510L. PROTOZOOLOGY.
(See list of courses offered at the Iowa Lakeside Laboratory.)

511. PARASITIC PROTOZOA.
(2-3) Cr. 3. Alt. S, offered 1973.
Prerequisite: Fifteen credits in zoology; 307, 311, or 505 recommended. Buttrey.
Taxonomy, morphology, life history, host-parasite relationships, evolution, identification, and medical significance of major groups of parasitic Protozoa.

512. HELMINTHOLOGY.
(2-6) Cr. 4. F.
Prerequisite: 307, 320. Ulmer.
Survey of the cestodes, trematodes, and nematodes parasitic in wildlife, laboratory animals, and man; selected vectors; identification, life histories, and host-parasite relationships. See also list of courses offered at the Iowa Lakeside Laboratory.

512L. HELMINTHOLOGY.
(See list of courses offered at the Iowa Lakeside Laboratory.)

527, 528. ADVANCED CELL BIOLOGY.
(C.Bio. 527, 528) See Cell Biology.

529. CYTOCHEMISTRY.
(0-6) Cr. 2. Alt. S, offered 1972.
Prerequisite: Permission of instructor; 428 recommended. Viles.
Techniques and procedures in cytological research.

538. EXPERIMENTAL EMBRYOLOGY.
(3-6) Cr. 5. S.
Prerequisite: 334, organic chemistry; biochemistry and histological techniques recommended. Baker.
Physiology of germ cells; parthenogenesis; marking and grafting experiments on living embryos; tissue-culture techniques.

540. WATERFOWL BIOLOGY AND CONSERVATION.
(2-3) Cr. 3. Alt. W, offered 1972.
Prerequisite: 320, 340. Weller.
Taxonomy, biology, and conservation of waterfowl of the world. Extended field trips.

550. COMPARATIVE ANIMAL PHYSIOLOGY.
(3-6) Cr. 5. S.
Prerequisite: 307 and 455, or permission of instructor. Redmond.
Functions in various phyla, with interpretations in terms of morphology, ecology, and evolution.

551, 552, 553. ADVANCED VERTEBRATE PHYSIOLOGY.
(3-3) Cr. 4 each. 551: F; 552: W; 553: S.SSII.
Prerequisite: 320 or V.An. 404 or equivalent; 455; one quarter organic chemistry; one quarter college physics. Griffith.
Primarily mammalian, systemic physiology with some cellular mechanisms. 551: Blood, nervous system, muscle. 552: Circulation, respiration, digestion. 553: Metabolism, excretion, endocrinology.

560. FISHERY ASPECTS OF WATER POLLUTION.
(3-0) Cr. 3. Alt. S, offered 1973.
Prerequisite: 405, permission of instructor. Bulkley.
Environmental requirements of fresh-water fish in relation to aquatic pollution.

563. FISH PROPAGATION.
(2-3) Cr. 3. Alt. S, offered 1972.
Prerequisite: 465. Bulkley.
Principles and techniques of fish propagation, hatchery operation, nutrition, and disease problems.

570. INSECT RESISTANCE IN CROP PLANTS.
(3-0) Cr. 3. W.
Prerequisite: 370 or 376; Gen. 301.
Principles and mechanisms of insect control by host plant resistance.

571. AQUATIC INSECTS.
(2-6) Cr. 4. Alt. S, offered 1973.
Prerequisite: 370, 405. Lewis.
Taxonomy, life history, and ecology of aquatic insects. Field trips.

572. INSECT MORPHOLOGY.
(2-9) Cr. 5. F.
Prerequisite: Fifteen credits in zoology, including 370. Lewis.
Intensive study of the external and internal anatomy and histology of insects.

574. MEDICAL ENTOMOLOGY.
(2-6) Cr. 4. F.
Prerequisite: Fifteen credits in zoology, including 370 or 376. Rowley.
Identification, life histories and control of arthropods attacking man, particularly those forms which are disease vectors. Field trips.

576, 577. SYSTEMATIC ENTOMOLOGY.
(3-6) Cr. 5 each. 576: W; 577: S.
Prerequisite: 572. Laffoon.
Classification, collection, and natural history of insects. Nomenclature and taxonomic practices. Field trips.

590. SPECIAL TOPICS.
Cr. 1 to 5 each time taken.
Prerequisite: Fifteen credits in zoology, permission of instructor.

COURSES FOR GRADUATE STUDENTS, major or minor

601. ZOOLOGICAL LITERATURE.
(3-0) Cr. 3. W.
Prerequisite: Fifteen credits in zoology. Knight.
Literature and classical authors of zoology and entomology; nomenclators; rules of zoological nomenclature.

602. ECOLOGICAL ENERGETICS.
(3-0) Cr. 3. W.
Prerequisite: 402, Bot. 424. Bachmann.
Theory and use of energy flow in analysis and description of ecosystems.

603. POPULATION ECOLOGY.
(5-0) Cr. 5. S.
Prerequisite: 402. Carlander.
Animal population fluctuation with emphasis on mechanics of maintaining optimal density.

604. ZOOGEOGRAPHY.
(3-0) Cr. 3. Alt. W, offered 1972.
Prerequisite: Fifteen credits in zoology. Lewis.
Geographic distribution of animals.

605. ADVANCED LIMNOLOGY.
(3-6) Cr. 5. F.
Prerequisite: 405. Bachmann.
Physical, chemical, and biological processes of lakes and streams and their relationships to biological productivity, ecological succession, and water quality. Limnological research techniques. Field trips.

607. ETHOLOGY.
(Psych. 607) (3-3) Cr. 4. Alt. F, offered 1971.
Prerequisite: 304. Shaw.
Concepts and methods of behavioral analysis.

612. ADVANCED PARASITOLOGY.
(3-0) Cr. 3. S.
Prerequisite: 512; 511 recommended. Ulmer.
Special phases in host-parasite relationships of parasitic protozoans, worms, and arthropods.

627. MICROANATOMY OF INVERTEBRATES.
(2-6) Cr. 4. Alt. S, offered 1973.
Prerequisite: 322, 334, 455. Viles.
Comparative histology, fine structure, and physiology of selected invertebrate systems.

639. SURVEY OF DEVELOPMENTAL ZOOLOGY.
(3-0) Cr. 3. W.
Prerequisite: 334, Gen. 301. Brown.
Discussion of molecular and cytological principles of development with emphasis on recent research.

645. WILDLIFE MANAGEMENT.
(3-3) Cr. 4. Alt. W, offered 1973.
Prerequisite: 241, 448. Weller.
Theories and principles of wildlife conservation, management practices, and special topics.

650. CELL PHYSIOLOGY.
(3-0 or 6) Cr. 3 or 5. S.
Prerequisite: 528, B.&B. 404, 405, 406. Dolphin.
Physical and biological analysis of cellular activities.

654. COMPARATIVE ENDOCRINOLOGY.
(3-0) Cr. 3. W.
Prerequisite: 551 or 552 or 553. Griffith.
Structure and function of endocrine systems of invertebrates and vertebrates.

655. INSECT PHYSIOLOGY.
(3-0 or 6) Cr. 3 or 5. W.
Prerequisite: 370, and 455 or 650. Mutchmor.
Life processes, organ functions of insects.

662. TECHNIQUES OF FISHERIES.
(3-3) Cr. 4. Alt. W, offered 1972.
Prerequisite: 465, Stat. 402. Muncy.
Critical analysis of methods for studying fish growth, food habits, population estimation, and mortality rates.

663. FISHERIES RESOURCES.
(3-0) Cr. 3. Alt. W, offered 1973.
Prerequisite: 465. Muncy.
Survey of fishery resources; analysis of problems concerned with commercial and sport fisheries and their management.

671. INSECT ECOLOGY AND POPULATION MANAGEMENT.
(3-3) Cr. 4. S.
Prerequisite: 370, 402; Stat. 101 or 401. Pedigo.
Insect populations, emphasizing outbreaks, assessment, and concepts of management.

674. ADVANCED MEDICAL ENTOMOLOGY.
(2-6) Cr. 4. Alt. W, offered 1973.
Prerequisite: 574. Rowley.
Vector-parasite relationships, ecology, and epidemiology of arthropod-borne animal diseases.

675. INSECT TOXICOLOGY.
(3-0) Cr. 3. Alt. S, offered 1972.
Prerequisite: 572, and 650 or 655. Dahm.
Chemistry and mode of action of modern insecticides.

698. SEMINAR IN CELL BIOLOGY.
(C.Bio. 698) See Cell Biology.

699. RESEARCH.

*COURSES OFFERED AT THE IOWA LAKESIDE LABORATORY

508L, 509L. AQUATIC ECOLOGY.
(8-24) Cr. 8 each.
Survey of local aquatic organisms and aquatic habitats; analysis of physiographic, physical, and chemical factors. Emphasis on field work, methodology, and basic ecological principles. Field trips.

510L. PROTOZOOLOGY.
(8-24) Cr. 8. SSII.
Prerequisite: Fifteen credits in zoology; 307 or 311 recommended.
Survey of the free-living and parasitic protozoans; evolution, identification, life cycles, and host-parasite relationships.

512L. HELMINTHOLOGY.
(8-24) Cr. 8. SSI.
Prerequisite: 307, 320.
Survey of the cestodes, trematodes, and nematodes parasitic in wildlife, laboratory animals, and man; study of selected vectors; identification, life histories, and host-parasite relationships emphasized.

590. SPECIAL TOPICS.
(See preceding section.)

699. RESEARCH.

*Permission of the instructor is a prerequisite for all courses offered at the Iowa Lakeside Laboratory. For current information concerning courses, registration, and housing, see the annual Iowa Lakeside Laboratory Bulletin. This bulletin is usually available from participating departments after Feb. 15.

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